Indiana Dunes National Lakeshore
Indiana

National Park Service
U.S. Department of the Interior

Shoreline Restoration and Management Plan/ Final Environmental Impact Statement

August 2014

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

SHORELINE RESTORATION AND MANAGEMENT PLAN / FINAL ENVIRONMENTAL IMPACT STATEMENT

Indiana Dunes National Lakeshore, Porter, Indiana

EXECUTIVE SUMMARY

The *Shoreline Restoration and Management Plan / Final Environmental Impact Statement* (EIS) has been prepared to provide scientifically-based alternatives for the restoration of natural sediment movement along the southern shore of Lake Michigan within and adjacent to Indiana Dunes National Lakeshore. The purpose of the plan / final EIS is to provide comprehensive guidance for restoring natural shoreline processes, preserving shoreline ecosystems, and providing opportunities for quality visitor experiences at Indiana Dunes National Lakeshore. The intent of the plan / final EIS is not to provide specific and detailed answers to every issue facing the park, but rather to provide a framework to assist National Park Service (NPS) managers, stakeholders, and locals governing bodies in making current and future decisions.

For the purpose of the plan / final EIS the shoreline has been divided into four reaches based on sediment erosion and accretion. Due to the natural process-driven interconnectivity of these areas the final EIS is formatted so that reaches 1 and 2, which extend from Crescent Dune to Willow Lane, and reaches 3 and 4, which extend from Willow Lane to the Gary-U.S. Steel East Breakwater, are discussed in the context of two independent sediment transport cells. The National Park Service will consider a no-action alternative (alternative A) in all reaches as a baseline of current conditions and management practices.

For reaches 1 and 2 seven alternatives were initially developed including the no-action alternative. All alternatives provide for beach nourishment at Crescent Dune differing in the source of material (upland versus dredged), method of placement (hydraulic versus mechanical), and frequency of placement (every year or every five years). Additionally, one of the alternatives incorporates a permanent bypass system, and another incorporates the construction of a temporary submerged cobble berm. Through a value analysis process the alternative that incorporated the submerged cobble berm was selected as the preferred alternative for reaches 1 and 2 for the plan / draft EIS. This alternative provided the best combination of strategies resulting in a high level of protection of natural resources while providing for a wide range of beneficial uses of the environment. However, public comment on the plan / draft EIS (July 2012) was extensive and ranged from support for the goals of the project to concerns about a number of aspects of the draft alternatives. The public was generally supportive of beach nourishment but there was consistent, negative response to the proposed cobble berm in alternative E (preferred alternative in the draft EIS).

It was determined through the draft EIS process that all alternatives meet park purposes and objectives while protecting park resources by minimizing impacts, and are consistent with the legislative intent of Indiana Dunes National Lakeshore, applicable federal laws, policies, and regulations.

The only variation between the alternatives is in the consistency of the aggregate (sediment/rock), frequency of placement, and method of placement. Therefore a new hybrid alternative was designed that incorporated desired aspects of multiple alternatives, which would meet park purposes and objectives, yet

addresses public concern with the submerged cobble berm.

The criteria critical to the selection of alternative E as the draft EIS preferred alternative for reaches 1 and 2 focused on the restoration of native materials (sediment, gravel, rock) to the shoreline and not necessarily on the method of placement (i.e., creating a submerged berm). The new hybrid alternative would provide the identical materials to the shoreline only through a direct placement process. The majority of material used for beach nourishment would be obtained from fine and medium grained sediments that could be hydraulically dredged (as in alternative C-1). The specific source location of the nourishment material would be determined in coordination with Indiana Department of Natural Resources (IDNR) in areas of accretion so that dredging activities would not disturb areas of equilibrium. The additional gravel and rock component would be obtained by implementing a portion of alternative B-1. Rather than using the inland mined source to provide the entire spectrum of beach nourishment, only the coarse component (gravels and rock), proposed under alternative E, would be hauled to the beach and mixed on-site with the hydraulically dredged sediments. The new hybrid alternative F incorporates the benefit of the gravel and rock materials from alternative E using the inland mined and hauled sources outlined in alternative B-1 with the hydraulically dredged sands outlined in alternative C-1.

For reaches 3 and 4 four alternatives were developed including the no-action alternative. All alternatives provide for beach nourishment at Portage Lakefront and Riverwalk differentiated by the frequency of nourishment (every year or every five years), and one includes the development of a permanent bypass system. Only dredged material was considered for these alternatives, because no viable access to the nourishment site exists for trucking in upland materials. Through a value analysis process the alternative that provides sediment nourishment material every five years through a combination of mechanical and hydrologic means was selected as the preferred alternative for reaches 3 and 4 in the draft EIS. This alternative is cost efficient and provides the greatest potential for both foredune creation and protection from major storm events. While the public was generally supportive of beach nourishment for reaches 3 and 4, there was negative response to alternative C-5 that provided beach nourishment every five years during the public comment on the plan / draft EIS. In response to the public's concerns, the preferred alternative for reaches 3 and 4 has been changed to alternative C-1 that provides for beach nourishment annually.

The plan / draft EIS was available for public comment for a period of 60 days commencing when the U.S. Environmental Protection Agency published the Notice of Availability in the Federal Register on September 14, 2012. One public meeting was held on October 23, 2012.

A copy of the plan / final EIS is available on the internet on the NPS Planning, Environment, and Public Comment website at: http://www.parkplanning.nps.gov/indu. The plan / final EIS can also be accessed through the park's home page at: http://www.nps.gov/indu. In addition, a limited number of hardcopies and CDs are available at the Indiana Dunes National National Lakeshore headquarters located at 1100 North Mineral Springs Road in Porter, Indiana. If you have any questions, please call Charles Morris, Environmental Protection Specialist, at 219-983-1352.

Paul Labovitz, Superintendent
Indiana Dunes National Lakeshore
1100 North Mineral Springs Road
Porter, Indiana 46304

SUMMARY

PURPOSE OF AND NEED FOR ACTION

The purpose of this *Shoreline Restoration and Management Plan / Final Environmental Impact Statement* (EIS) is to provide comprehensive guidance for restoring natural shoreline processes, preserving the shoreline ecosystem, and providing opportunities for quality visitor experiences at Indiana Dunes National Lakeshore. The purposes of this plan / final EIS are as follows:

- Ensure that the foundation for decision-making has been developed in consultation with the public and is adopted by NPS leadership after sufficient analysis of the benefits and impacts of alternative courses of action.
- Develop strategies that would support the reestablishment of more sustainable shoreline sediment movement and a more natural ecosystem of shoreline vegetation, foredune and dune complexes.
- Define desired resource conditions for the shoreline, foredunes and dunes.
- Identify approaches for shoreline restoration and management that are consistent with a regional approach to management of the lakeshore that encourages maintenance of a natural shoreline and functioning ecosystems.

Prior to industrial and residential development along Lake Michigan, the shoreline was comprised of a highly diverse landscape including swamp and marsh lands, dunes, oak savanna, and prairies. The natural shoreline processes along southern Lake Michigan have been heavily impacted by the construction of numerous navigational harbors and hardened (man-made) structures that have greatly affected the integrity and sustainability of the natural landscape. These structures altered Lake Michigan's natural littoral drift, resulting in areas of sediment accretion (accumulation) east (updrift) of Michigan City and the Port of Indiana, and sediment starvation to the west (downdrift) of these same harbors. The lack of continued sediment replenishment from natural littoral drift has resulted in extensive beach and dune erosion which threatens both public and private resources. Although the U.S. Army Corps of Engineers (COE) conducts beach nourishment on an intermittent basis and the staff at Indiana Dunes National Lakeshore conduct certain resource management actions to protect resources (such as sensitive plant and animal habitats), no specific shoreline restoration plan exists, and the impact of severe shoreline and beach erosion would compromise the park's outstanding ecological and biological diversity found within its boundaries. This plan / final EIS is needed to:

- Address the severe shoreline and beach erosion and the impacts on dune ecology that are caused by interruptions to the natural processes along the shoreline, including the movement of sediment.
- Address the adverse impacts to the fragile shoreline ecosystem caused by the interrupted natural processes and sediment movement.
- Identify a series of management actions that can be implemented by park staff, as needed, to provide a balance between protection of the shoreline ecosystem and appropriate visitor enjoyment of the park.

OBJECTIVES IN TAKING ACTION

Objectives define what must be achieved for an action to be considered a success. Alternatives selected for detailed analysis must meet all objectives and must also resolve the purpose of and need for action.

Using the park's enabling legislation, mandates, and direction in other planning documents as well as NPS service-wide objectives, NPS *Management Policies 2006*, and the NPS *Organic Act of 1916*, the staff of Indiana Dunes National Lakeshore identified

the following management objectives relative to shoreline management at the park.

Shoreline Restoration

- Develop strategies that would support the reestablishment of more sustainable shoreline sediment movement and a more natural ecosystem of shoreline vegetation, foredune and dune complex.

Exotic and Invasive Species

- Develop strategies to identify, manage, and remove aquatic and terrestrial nonnative and invasive species.
- Develop strategies to support ongoing management efforts to remove aquatic and terrestrial nonnative and invasive species, and to prevent conditions detrimental to those efforts.

Management Methodology

- Determine shoreline desired conditions that would serve as thresholds for management actions within Indiana Dunes National Lakeshore.
- Develop and implement an adaptive management approach for maintaining a sustainable shoreline ecosystem within Indiana Dunes National Lakeshore.

ALTERNATIVES CONSIDERED

For the purpose of this plan / final EIS, the shoreline has been divided into four reaches based on accretion and erosion rates. Proposed alternatives are presented for reaches 1 and 2 and reaches 3 and 4. Under all proposed action alternatives, the sediment used for beach nourishment would be compatible with native site sediment, meaning similar in terms of color, shape, size, mineralogy, compaction, organic content, and texture. Beach nourishment material would be free of harmful chemical contaminants, trash, debris, and large pieces of organic material. Placement of the nourishment material would be conducted in a manner to avoid or minimize potential impacts on both natural resources and visitors of the park. The alternatives considered addressed the public's main concerns of protecting habitat, maintaining a natural viewshed, and not causing additional disruptions to sediment movement in the area.

Once this plan is completed, several of the nourishment activities proposed under the alternatives could be implemented without further compliance or study. Other more detailed studies and plans would be needed before some specific actions could be implemented, including design specifications. These additional plans and studies would include an in-depth analysis of potential impacts.

Reaches 1 and 2

The National Park Service would continue current management practices. For the foreseeable future, there would be no new actions taken to restore the park shoreline. For reaches 1 and 2 seven alternatives were developed including the no-action alternative. All alternatives provide for beach nourishment at Crescent Dune differing in the source of material (upland versus dredged), method of placement (hydraulic versus mechanical), and frequency of placement (every year or every five years). Additionally, one of the alternatives incorporates a permanent bypass system, and another incorporates the construction of a temporary submerged cobble berm. Through a value analysis process the alternative that incorporated the submerged cobble berm was selected as the preferred alternative for reaches 1 and 2. This alternative provided the best combination of strategies resulting in a high level of protection of natural resources while providing for a wide range of beneficial uses of the environment.

Public involvement and comment on the plan / draft EIS was extensive, ranging from support to concern with various aspects of the alternatives presented. While the public was generally supportive of beach nourishment, there was consistent, negative response to the submerged cobble berm. Therefore the National Park Service chose to review the array of alternatives to determine the feasibility of both satisfying public concern and achieving the project goals through the development of a new hybrid alternative.

A new hybrid alternative was developed for reaches 1 and 2 that incorporates the full range of native materials using an approach other than the submerged berm would achieve the same objectives. The majority of material used for beach nourishment would be obtained from fine and medium grained sediments that would be hydraulically dredged. The additional gravel and rock component would be obtained from an upland source. Thus, a new hybrid alternative was created as the new preferred alternative for reaches 1 and 2.

Reaches 3 and 4

The National Park Service would continue current management practices. For the foreseeable future, there would be no new actions taken to restore the park shoreline. For reaches 3 and 4 four alternatives were developed including the no-action alternative. All alternatives provide for beach nourishment at Portage Lakefront and Riverwalk differentiated by the frequency of nourishment (every year or every five years), and one includes the development of a permanent bypass system. Only dredged material was considered for these alternatives, because no viable access to the nourishment site exists for trucking in upland materials. Through a value analysis process the alternative that provides sediment nourishment every five years through a combination of mechanical and hydrologic means was selected as the preferred alternative for reaches 3 and 4. This alternative is cost efficient and provides the greatest potential for both foredune creation and protection from major storm events. However, in response to public concerns related to the large volume of material that would be placed on the beach under the preferred alternative the frequency of placement was changed from every five years to annual beach nourishment activities. The preferred alternative for reaches 3 and 4 is now alternative C-1.

Terrestrial Management Actions

In addition to the shoreline restoration alternatives, natural resource management strategies are proposed for the protection and improvement of the park's terrestrial ecosystem. Plant communities and physiography are continually changing with the disturbance-prone habitats of the foredune complex. The foredune and dune complex encourages biological diversity unique to this region of the country. Migratory bird habitat, intradunal wetlands, and the various stages of dune succession are critical components of the park. The National Park Service is responsible for the protection of these sensitive habitats. Protection is currently accomplished with the following management strategies:

- preservation or restoration of sensitive habitat
- management of nonnative invasive plant species
- reduction of anthropogenic influences on native dune vegetation and critical habitat

ENVIRONMENTAL CONSEQUENCES

The analysis of environmental consequences considers the actions being proposed and the cumulative effects from occurrences inside and outside Indiana Dunes National Lakeshore. The analysis addresses the potential environmental consequences of the actions for coastal processes, including

sediment transport and dune formation, aquatic fauna, terrestrial habitat, threatened and endangered species and species of concern, wetlands and pannes, soundscape, visitor experience, and park operations.

In analyzing the impacts on natural resources, all action alternatives would benefit coastal processes. There would be adverse effects on aquatic fauna, terrestrial habitat, threatened and endangered species and species of concern, and soundscape as a result of activities associated with the placement of nourishment material. The duration and intensity of these effects would vary depending on the source of the nourishment material (i.e., upland or dredged) and the volume of nourishment material proposed under each alternative. Under the NPS preferred alternative (alternative F) in reaches 1 and 2, effects on all resources would be no greater than moderate and adverse. Under the NPS preferred alternative (alternative C-1) in reaches 3 and 4, effects would be no greater than short-term, minor, and adverse on all resources.

However, under all the action alternatives, the impacted resources (e.g., coastal processes, aquatic fauna, terrestrial habitat, threatened and endangered species and species of concern, and soundscape) would benefit in the long term from the reduction of severe shoreline and beach erosion and the creation of a more natural ecosystem of shoreline vegetation and foredune and dune complexes and processes.

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Acronyms

CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
COE	U.S. Army Corps of Engineers
CSSC	Chicago Sanitary and Ship Canal
CZMA	Coastal Zone Management Act
dBA	A-weighted decibel
E. coli	*Escherichia coli*
EA	environmental assessment
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ft./yr.	feet per year
FWS	U.S. Fish and Wildlife Service
GHG	greenhouse gas
IDNR	Indiana Department of Natural Resources
LIDAR	Light Detection and Ranging
LWD	Low Water Datum
m^3	cubic meters
$mtCO_2e$	metric tons of carbon dioxide equivalent
NEPA	National Environmental Policy Act of 1969, as amended
NHPA	National Historic Preservation Act, as amended
NIPSCO	Northern Indiana Public Service Company
NPS	National Park Service
PEPC	Planning Environment and Public Comment
SHPO	state historic preservation officer
U.S.	United States
USC	United States Code
USGS	U.S. Geological Survey
yd^3	cubic yards

A GUIDE TO THIS DOCUMENT

This *Shoreline Restoration and Management Plan / Draft Environmental Impact Statement* (EIS) is organized into five chapters plus appendixes. Each section is described briefly below.

The "Purpose and Need for Action" chapter describes the context for the entire final EIS. It explains why this plan is being prepared and what issues it addresses. It provides guidance (e.g., park purpose, significance, resources and values, special mandates, and service-wide laws and policies) for the alternatives that are considered. The "Purpose and Need for Action" chapter also describes how this plan relates to other plans and projects and identifies impact topics to be discussed relative to the no-action alternatives. It also includes a discussion of impact topics that were dismissed from detailed analysis.

"The Alternatives" chapter discusses management zones and the management alternatives. Mitigating measures for minimizing or eliminating impacts of some proposed actions are presented. A section on the selection of the preferred alternative and environmentally preferable alternative follows.

The "Affected Environment" chapter describes areas and resources that would be affected by actions that are part of the various alternatives — including coastal processes, aquatic fauna, terrestrial habitat, threatened and endangered species and species of concern, wetlands and pannes, soundscape, visitor experience, and park operations.

The "Environmental Consequences" chapter analyzes the impacts of implementing the alternatives. Approaches used to assess impacts are outlined at the beginning of the "Environmental Consequences" chapter.

The "Consultation and Coordination" chapter describes the history of public and agency coordination during the planning effort; it also lists agencies and organizations that will receive copies of the final EIS.

The appendixes present information on enabling legislation, technical references, species lists, and initial agency consultation.

CHAPTER 1
Purpose and Need for Action

INTRODUCTION

Indiana Dunes National Lakeshore was created by the United States (U.S.) Congress in 1966, and is one of four national lakeshores in the U.S., all on the Great Lakes. Legislation providing for the establishment of the Indiana Dunes National Lakeshore is included in Appendix A: Enabling Legislation. These national lakeshores share certain challenges associated with balancing impacts of human actions within fragile natural environments. Indiana Dunes National Lakeshore faces challenges unique among national lakeshores in managing and operating within a natural environment that has been considerably altered.

Prior to industrial and residential development along Lake Michigan, the shoreline was comprised of a highly diverse landscape including swamp and marsh lands, dunes, oak savanna, and prairies. The natural shoreline processes along southern Lake Michigan have been heavily impacted by the construction of numerous navigational harbors and hardened (man-made) structures that have greatly affected the integrity and sustainability of the natural landscape. These structures outside of Indiana Dunes National Lakeshore altered Lake Michigan's natural east-to-west littoral drift (or longshore drift, defined as movement of sediment along the coast). Lake Michigan's waves usually surge onto the beach at an oblique angle with their swash taking sediment up and along the beach, resulting in areas of sediment accretion (accumulation) east (updrift) of Michigan City and Port of Indiana, and sediment starvation to the west (downdrift) of these same harbors. The lack of continued sediment replenishment from natural littoral drift has resulted in extensive beach and dune erosion which threatens both public and private resources.

The continued erosion along Indiana Dunes National Lakeshore west of Michigan City and Port of Indiana has been mitigated to a certain degree through beach nourishment and offshore placement of sediment conducted by the U.S. Army Corps of Engineers (COE) (see "The Alternatives" chapter for details). Beach nourishment or replenishment is a process by which sediment lost through littoral drift or erosion is replaced from sources outside of the eroding beach. Due to the continuing issue of erosion along the lakeshore and the lack of a systematic means of finding a remedy, the National Park Service decided to address the issue with a shoreline restoration management plan.

The National Park Service began public involvement early. Conversations have been held for years with state, federal, and municipal entities within the boundaries of the Indiana Dunes National Lakeshore about the problems. Once the decision was made to move forward with the development of a plan, the National Park Service began a formal scoping process, which is an open process for determining the scope of a proposed action or project and for identifying issues related to the project (see the "Consultation and Coordination" chapter for more detail). The National Park Service actively engaged the public, stakeholders, and government officials at the federal, state, and local levels through the use of public meetings and project newsletters and by providing the opportunity to provide comments.

The National Park Service invited the COE and the State of Indiana to be cooperating agencies on this plan / final EIS to give them the opportunity to provide information in their areas of technical expertise and to review and comment on early versions of this plan / final EIS. The COE agreed to be a cooperating agency and a Memorandum of Understanding was executed between the National Park Service and the COE (included in Appendix B: Initial Agency Coordination). The State of Indiana declined to participate as a cooperating agency.

The development of this plan / final EIS was facilitated by funds provided to the National Park Service through the Great Lakes Restoration Initiative, administered by the U.S. Environmental Protection Agency (EPA). The Great Lakes Restoration Initiative, the largest investment in the Great Lakes in two decades, involves a task force of 11 federal agencies which developed a plan to cover five urgent focus areas, including:

- cleaning up toxins and areas of concern
- combating invasive species
- promoting nearshore health by protecting watersheds from polluted run-off
- restoring wetlands and other habitats
- working with partners on outreach

PURPOSE AND NEED FOR THE PLAN

PURPOSE

The purpose of this plan is to provide comprehensive guidance for restoring natural shoreline processes, preserving the shoreline ecosystem, and providing opportunities for quality visitor experiences at Indiana Dunes National Lakeshore. The approved plan will guide the National Park Service (NPS) in best fulfilling the park's purpose.

This plan describes how the National Park Service generally proposes to manage the shoreline at Indiana Dunes National Lakeshore for the next 20 years or more. In particular it describes approaches to beach nourishment within the park and proposes additional strategies to address the shoreline management issues. Additional planning and environmental compliance would be completed as necessary to implement this plan. The plan should:

- Ensure that the foundation for decision-making has been developed in consultation with the public and is adopted by NPS leadership after sufficient analysis of the benefits and impacts of alternative courses of action.
- Develop strategies that would support the reestablishment of more sustainable shoreline sediment movement and a more natural ecosystem of shoreline vegetation, foredune and dune complexes.
- Define desired resource conditions for the shoreline, foredunes and dunes.
- Identify approaches for shoreline restoration and management that are consistent with a regional approach to management of the lakeshore that encourages maintenance of a natural shoreline and functioning ecosystems.

NEED

The plan is needed to:

- Address the severe shoreline and beach erosion and the impacts on dune ecology that are caused by interruptions to the natural processes along the shoreline, including the movement of sediment.
- Address the adverse impacts to the fragile shoreline ecosystem caused by the interrupted natural processes and sediment movement.
- Identify a series of management actions that can be implemented by park staff, as needed, to provide a balance between protection of the shoreline ecosystem and appropriate visitor enjoyment of the park.

GOALS AND OBJECTIVES FOR TAKING ACTION

Any plan the park develops must be consistent with the laws, regulations, and policies that guide the National Park Service. Objectives are "what must be achieved to a large degree for the action to be considered a success" (NPS 2001). All alternatives selected for detailed analysis must meet all objectives to a large degree, and they must resolve the purpose and need for action. Objectives for shoreline restoration must be grounded in the park's enabling legislation, purpose,

significance, and mission goals, and they must be compatible with the direction and guidance provided by the park's Statement for Management. See Appendix A: Enabling Legislation for additional information. The following objectives related to shoreline restoration were developed for this plan.

Shoreline Restoration

- Develop strategies that would support the reestablishment of more sustainable shoreline sediment movement and a more natural ecosystem of shoreline vegetation, foredune and dune complexes.

Exotic and Invasive Species

- Develop strategies to identify, manage, and remove aquatic and terrestrial exotic and invasive species; and
- Develop strategies to support ongoing management efforts to remove aquatic and terrestrial exotic and invasive species, and to prevent conditions detrimental to those efforts.

Management Methodology

- Determine shoreline desired conditions that would serve as thresholds for management actions within Indiana Dunes National Lakeshore; and
- Develop and implement an adaptive management approach for maintaining a sustainable shoreline ecosystem within Indiana Dunes National Lakeshore.

To meet the goals and objectives of the project, this plan proposes and analyzes various alternatives and their respective impacts on the environment. This final EIS has been prepared in accordance with the National Environmental Policy Act of 1969, as amended (NEPA) and regulations of the Council on Environmental Quality (CEQ) (40 Code of Federal Regulations [CFR] 1508.9).

PROJECT LOCATION

Indiana Dunes National Lakeshore is approximately 50 miles southeast of Chicago, Illinois, in the counties of Lake, Porter, and LaPorte in northwest Indiana's industrial-urban corridor. The project area encompasses 21 miles of the shoreline (see Map 1-1: Park Map). The park is located at the southernmost point of Lake Michigan. Under this plan, the National Park Service would implement specific restoration and management actions within its boundaries. As shown on Map 1-1: Park Map, Indiana Dunes National Lakeshore shares its boundaries with various residential, agricultural, and industrial developments.

The project area for this plan / final EIS does not include the entire Indiana Dunes National Lakeshore; it includes only the shoreline, foredunes, and dunes as generally shown on the Project Area Map (Map 1-2). For purposes of analysis and the development of shoreline restoration actions, the project planning team considered the entirety of the Lake Michigan shoreline along Indiana Dunes National Lakeshore. The project encompasses the area from the water's edge outward to the depth at which sediment on the lake bottom is no longer affected by wave action, and from the water's edge inland to include the foredune and dune complexes. Foredunes are low, very active dunes that parallel the beach and are named for their position as the first (fore) dunes inland from the beach.

Legend

- Indiana Dunes National Lakeshore
- State and Local Parkland

N

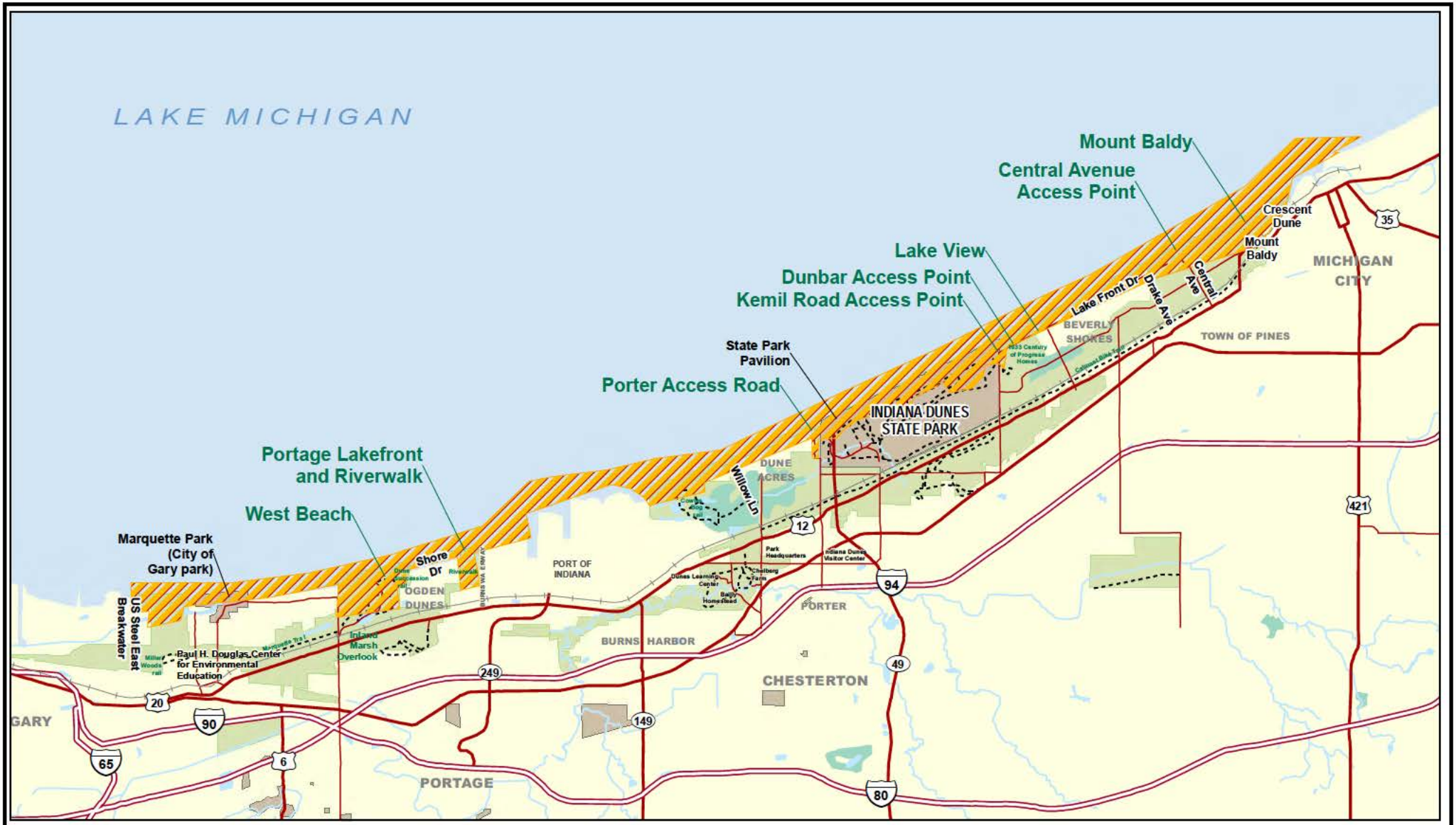
6,000 0 6,000 Feet

1 inch = 12,000 feet

MAP 1-1
PARK MAP
Indiana Dunes National Lakeshore
Shoreline Restoration and Management Plan / Environmental Impact Statement

National Park Service / U.S. Department of the Interior

March 2012



Legend

Project Area

N

6,000 0 6,000 Feet

1 inch = 12,000 feet

MAP 1-2
PROJECT AREA MAP

Indiana Dunes National Lakeshore
Shoreline Restoration and Management
Plan / Environmental Impact Statement

National Park Service / U.S. Department of the Interior
March 2012

PARK BACKGROUND

HISTORY OF INDIANA DUNES NATIONAL LAKESHORE

Henry Cowles, a botanist from the University of Chicago who long championed the study of plant ecology, helped bring international attention to the intricate ecosystems of Indiana's dunes. Residents of the area and the region recognized the value of the dunes, and first proposed a national park in 1915. While supporters of the idea continued to pursue this effort for the next 50 years, other parties sought industrial uses and proposed the creation of the Port of Indiana.

In 1963, President John F. Kennedy proposed "the Kennedy Compromise" that allowed both a national park and a port. In 1966, Illinois Senator Paul H. Douglas sponsored legislation (Public Law 89-761) that authorized Indiana Dunes National Lakeshore, which included 8,330 acres of land and water.

Indiana Dunes National Lakeshore enabling legislation was passed by Congress on November 5, 1966 to:

> Preserve for the educational, inspirational, and recreational use of the public certain portions of the Indiana Dunes and other areas of scenic, scientific, and historic interest and recreational value in the State of Indiana.

Four subsequent expansions (1976, 1980, 1986, and 1992) increased the size of the park to more than 15,000 acres.

OVERVIEW OF THE PARK'S ECOSYSTEM

Biological diversity is one of the most important features of Indiana Dunes National Lakeshore. This diversity is many times greater than that of most areas of similar size because the park is in several ecological transition zones, including where the northern conifers meet the temperate hardwood forests of the northern and eastern U.S. and the tallgrass prairies of the Midwest. Indiana Dunes National Lakeshore contains more than 1,445 species of vascular plants, of which 1,135 are native. Indiana Dunes National Lakeshore ranks third highest with respect to floristic diversity within all national park system units. This exceptional biological diversity was a primary reason for the establishment of Indiana Dunes National Lakeshore.

Indiana Dunes National Lakeshore is located in the midst of an urban and industrial setting. The setting, combined with increased visitation at the park, has resulted in potential threats to the park's ecosystem. For example, a number of sensitive and rare plant species have been extirpated from the park due to human impacts.

INDIANA DUNES NATIONAL LAKESHORE'S PURPOSE AND SIGNIFICANCE

Park Purpose

The park purpose is a clear statement of why Congress established Indiana Dunes National Lakeshore. Statements of purpose are grounded in a thorough analysis of the park's legislation and legislative history. Purpose statements go beyond a restatement of the law to document shared assumptions about what the law means in terms specific to the park.

The purpose of Indiana Dunes National Lakeshore is to preserve, restore, and protect outstanding ecological and biological diversity along with geologic features that characterize the southern shore of Lake Michigan. The park also provides opportunities for the

public to experience natural scenic open spaces, historic features, and educational, scientific, inspirational, and recreational opportunities in proximity to urban areas.

Park Significance

- The park contains exceptional biological diversity and outstanding floral richness, resulting from the combination of complex geologic processes and the convergence of several North American life zones.
- The park's cultural resources represent the cultural evolution of northern Indiana from prehistoric times to the present day.
- The park's extensive reach of undeveloped dunes provides educational, inspirational, and recreational opportunities within a one-hour drive of a large metropolitan area.
- The park offers outstanding opportunities for scientific research due to the diversity and complexity of its natural systems and its history as a dynamic laboratory for early plant succession and faunal studies.
- The dunes provide a striking physical and emotional relief to the surrounding highly developed and flat landscape.

RELATIONSHIP OF PARK PLANNING DOCUMENTS TO OTHER GUIDING LAWS, POLICIES, PLANS, AND CONSTRAINTS

FEDERAL LAWS AND ORDERS

Several federal laws and orders influence the actions presented in this plan / final EIS and must be considered and adhered to. The following sections present federal laws and orders that are relevant to this plan / final EIS.

Endangered Species Act of 1973, as Amended

The purpose of the Endangered Species Act is to conserve "the ecosystems upon which endangered and threatened species depend" and to conserve and recover listed species. Endangered means a species is in danger of extinction; threatened means a species is likely to become endangered. The law also requires federal agencies to consult with the U.S. Fish and Wildlife Service (FWS) to ensure that the actions they take, including actions chosen under the proposed alternatives presented in the final EIS, do not jeopardize listed species or designated critical habitat.

Coastal Zone Management Act of 1972

The Coastal Zone Management Act (CZMA) encourages the management of coastal zone areas and provides grants to be used in maintaining coastal zone areas. It requires that federal agencies be consistent in enforcing the policies of state coastal zone management programs when conducting or supporting activities that affect a coastal zone. It is intended to ensure that federal activities are consistent with state programs for the protection and, where possible, enhancement of the nation's coastal zones. The Act's definition of a coastal zone includes coastal waters extending to the outer limit of state submerged land title and ownership, and adjacent shorelines and land extending inward to the extent necessary to effectively manage shorelines. A coastal zone includes islands, beaches, transitional and intertidal areas, and salt marshes.

To comply with the CZMA, the federal agency must identify activities that would affect the coastal zone defined above, including restoration projects, and review the state coastal zone management plan to determine whether the activity would be consistent with the plan.

Executive Order 11990, "Protection of Wetlands"

Executive Order 11990, "Protection of Wetlands" directs the National Park Service to avoid, to the extent possible, the long- and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative.

NPS LAWS, POLICIES, AND GUIDANCE

NPS Organic Act of 1916

By enacting the *NPS Organic Act of 1916*, Congress directed the National Park Service to manage units of the national park system "to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (16 *United States Code* [USC] 1). The Redwood National Park Expansion Act of 1978 reiterates this mandate by stating that the National Park Service must conduct its actions in a manner that will ensure no "derogation of the values and purposes for which these various areas have been

established, except as may have been or shall be directly and specifically provided by Congress" (16 USC 1a-1).

National Park Service *Management Policies 2006*

The National Park Service *Management Policies 2006* provides further interpretation and policy guidance relative to laws, proclamations, executive orders, regulations, and specific directives. Several sections from NPS *Management Policies 2006* are relevant to aquatic and terrestrial ecological management in Indiana Dunes National Lakeshore, as described below.

The National Park Service *Management Policies 2006* instructs park units to:

- "Develop effective strategies, methods, and technologies to (1) restore disturbed resources, and (2) predict, avoid, or minimize adverse impacts on natural and cultural resources and on visitors and related activities."
- "Determine the causes of natural resource management problems and identify alternative strategies for potentially resolving them" (NPS 2006, section 4.2.1).

The National Park Service *Management Policies 2006* also instructs park units to maintain, as part of the natural ecosystems of parks, all native plants and animals. The National Park Service achieves this maintenance by "preserving and restoring the natural abundances, diversities, dynamics, distributions, habitats, and behaviors of native plant and animal populations and the communities and ecosystems in which they occur" (NPS 2006, section 4.4.1).

Furthermore, the National Park Service "will adopt park resource preservation, development, and use management strategies that are intended to maintain the natural population fluctuations and processes that influence the dynamics of individual plant and animal populations, groups of plant and animal populations, and migratory animal populations in parks" (NPS 2006, section 4.4.1.1).

Whenever the National Park Service identifies a possible need for reducing the size of a park plant or animal population, the decision is based on scientifically valid resource information that has been obtained through consultation with technical experts, literature review, inventory, monitoring, or research. The planning team was assembled to complete this task (NPS 2006, section 4.4.2.1).

Also, "whenever possible, natural processes will be relied upon to maintain native plant and animal species, and to influence natural fluctuations in populations of these species. The [National Park Service] may intervene to manage individuals or populations of native species"...management is necessary to protect specific cultural resources of parks; and to protect rare, threatened, or endangered species (NPS 2006, section 4.4.2).

The National Park Service *Management Policies 2006* indicates, "Natural shoreline processes (such as erosion, deposition, dune formation, overwash, inlet formation, and shoreline migration) will be allowed to continue without interference. Where human activities or structures have altered the nature or rate of natural shoreline processes, the National Park Service will, in consultation with appropriate state and federal agencies, investigate alternatives for mitigating the effects of such activities or structures and for restoring natural conditions. The National Park Service will comply with the provisions of Executive Order 11988, 'Floodplain Management,' and state coastal zone management plans prepared under the Coastal Zone Management Act of 1972" (NPS 2006, section 4.8.1.1). The language in section 4.8.1.1 goes on to state that the National Park Service will use the most feasible and effective methods to achieve natural resource management objectives while minimizing impacts.

Impairment. In addition to requiring the restoration of disturbed resources and the resolution of natural resource management problems, NPS *Management Policies 2006* (Section 1.4) requires analysis of potential effects to determine whether proposed actions would impair a park's resources and values.

The purpose of the national park system, established by the *Organic Act of 1916* and reaffirmed by the General Authorities Act, as amended, begins with a mandate to conserve park resources and values. National Park Service managers must seek ways to avoid, or to minimize to the greatest degree practicable, adverse impacts on park resources and values. However, the laws do give the National Park Service management discretion to allow impacts on park resources and values when necessary and appropriate to fulfill the purposes of the park. That discretion is limited by the statutory requirement that the National Park Service must leave resources and values unimpaired unless a particular law directly and specifically provides otherwise.

The prohibited impairment is an impact that, in the professional judgment of the responsible NPS manager, would harm the integrity of park resources or values, including opportunities that would otherwise be present for the enjoyment of those resources or values (NPS 2006). Whether an impact meets this definition depends on the particular resource(s) that would be affected; the severity, duration, and timing of the impact; the direct and indirect effects of the impact; and the cumulative effects in relation to the impact.

An impact on any park resource or value may, but does not necessarily, constitute impairment. An impact would be more likely to constitute impairment to the extent that it affects a resource or value whose conservation is:

- necessary to fulfill specific purposes identified in the establishing legislation or proclamation of the park
- key to the natural or cultural integrity of the park or to opportunities for enjoyment of the park
- identified in the park's General Management Plan or other relevant NPS planning documents as being of significance

An impact would be less likely to constitute impairment if it is an unavoidable result of an action necessary to preserve or restore the integrity of park resources or values and could not be further mitigated.

Impairment can result from visitor activities, NPS administrative activities, or activities undertaken by concessioners, contractors, and others operating in the park. Impairment can also result from sources or activities outside the park. Impairment findings do not apply to visitor experience, socioeconomics, public health and safety, environmental justice, land use, and park operations because impairment findings relate back to park resources and values. A determination of impairment will be prepared and made part of the Record of Decision for this plan / final EIS.

Director's Order 12: *Conservation Planning, Environmental Impacts Analysis, and Decision-making*

NPS Director's Order 12: *Conservation Planning, Environmental Impacts Analysis, and Decision-making* and its accompanying handbook (NPS 2001) lay the groundwork for how the National Park Service complies with NEPA. Director's Order 12 and the handbook set forth a planning process for incorporating scientific and technical information and establishing an administrative record for NPS projects.

Director's Order 12 requires that impacts on park resources be analyzed in terms of their context, duration, and intensity. It is crucial for the public and decision makers to understand the implications of those impacts

in the short and long term, cumulatively, and within context, based on an understanding and interpretation by resource professionals and specialists.

Natural Resource Management Reference Manual 77

The Natural Resource Management Reference Manual 77 provides guidance for NPS employees responsible for managing, conserving, and protecting the natural resources found in national park system units.

Director's Order 77-1: Wetland Protection and Procedural Manual #77-1

The purpose of Director's Order 77-1: *Wetland Protection* and *Procedural Manual #77-1* is to establish NPS policies, requirements, and standards for implementing Executive Order 11990, "Protection of Wetlands" (42 CFR 26961). Executive Order 11990 was issued in 1977 in order "to avoid to the extent possible the long- and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative."

Temporary impacts to the existing beach wetlands would be unavoidable within the specific site where the shoreline would be nourished. The post-restoration shoreline would be expected to result in the same acreage of the same wetland type as exists now, but shifted northward (or at least maintained in its present position) because a comparable shoreline profile is expected to develop. Since there would be no net loss of the beach wetland habitat, the project could be considered under the Restoration Exception in section 4.2.1 (h) of NPS Director's Order 77-1: *Wetland Protection* and *Procedural Manual #77-1*.

Draft NPS Procedure Manual – Sediment Restoration and Beach Nourishment Guidelines (2011)

The purpose of the sediment restoration and beach nourishment guidelines is to assist NPS staff in planning and managing coastal sediment restoration projects. It focuses on shoreline and nearshore projects. The manual provides tools for resource managers to use in interfacing with partners that are completing technical designs to protect park resources. The guidelines provide a unified approach to coastal sediment management.

The information presented in this manual is focused on regions where extensive information was available. The recommendations presented are meant to be useful to parks considering coastal sediment restoration, but do not represent official NPS policy.

PARK PLANNING DOCUMENTS FOR INDIANA DUNES NATIONAL LAKESHORE

Indiana Dunes National Lakeshore does not exist separately from its surroundings. Several plans for areas within or near Indiana Dunes National Lakeshore could influence or be influenced by actions presented in this plan / final EIS and must be considered. These relevant plans and studies are described below.

General Management Plan, 1997

The General Management Plan for Indiana Dunes National Lakeshore (1997a) is a comprehensive document for the park that combines the West Unit General Management Plan Amendment (1992), the Little Calumet River Corridor Plan (1991), and the East Unit General Management Plan Amendment (1997b). It defines the management philosophy and goals for the park for the next 20 years.

The 1997 General Management Plan summarizes and consolidates revisions made to the 1980 General Management Plan and discusses current and desired conditions related to natural resource management, transportation and parking, river access, and visitor use for each area of the park.

Implementation of the proposed project for shoreline restoration and management is consistent with the park's General Management Plan.

Fire Management Plan, 2004

The National Park Service *Management Policies 2006* require that all NPS areas with vegetation capable of sustaining fire develop a Fire Management Plan (USDA, USDI, *et al.* 1998). The purpose of this plan is to outline actions that would be taken by the park in meeting the fire management goals established for the park.

A Fire Management Plan is a detailed program of action to implement fire management policy and objectives. This plan outlines how wildland fires would be safely suppressed in an efficient, cost-effective manner; the role wildland fire management plays in the protection and management of natural and cultural resources; and how public and private property is to be protected from the impacts of wildland fires.

Invasive Plant Management Plan, Ongoing

The National Park Service is in the process of preparing an environmental assessment (EA) for a Great Lakes Invasive Plant Management Plan for Indiana Dunes National Lakeshore and several other national parks in the Great Lakes region.

The Invasive Plant Management Plan /EA is based on integrated pest management. Integrated pest management is defined as a decision-making process that coordinates knowledge of pest biology, the environment, and available technology to prevent unacceptable levels of pest damage by cost-effective means, while posing the least possible risk to people and park resources. The scope of the Great Lakes Invasive Plant Management Plan /EA would be to identify long-term invasive plant management tools that would reduce the impacts of (or threats from) invasive plants to natural and cultural resources and provide opportunities for restoring native plant communities and cultural landscapes. The Invasive Plant Management Plan /EA would provide strategies for park staff to manage terrestrial and emergent wetland invasive plants on NPS-managed lands within the designated boundaries of the parks.

Memorandum on Mount Baldy Management Actions, 2011

The memorandum on Mount Baldy Management Actions from the Superintendent of Indiana Dunes National Lakeshore (NPS 2011a) describes current issues and potential management strategies for protection of Mount Baldy, the single most popular site for visitors to the park, from continued erosion. Similar problems elsewhere at the park were also cited, although the initial focus of management actions would be on Mount Baldy.

This memorandum describes the findings of an October 2010 management workshop on the subject, and outlined a series of goals with potential response strategies for each, as follows:

- stop people from going up or down the south slope
- restore areas denuded of vegetation by human actions
- designate an appropriate route from the top of the dune back to the parking lot to reduce damage to vegetation and the

potential for injuries caused by going down the south slope
- reduce social trail impacts to the resource
- achieve visitor compliance through education

OTHER PLANNING DOCUMENTS FOR SOUTHERN LAKE MICHIGAN

A number of existing external plans pertaining to the southern Lake Michigan shoreline area in northwest Indiana provide important context for this plan / final EIS. While this plan / final EIS need not be entirely consistent with these external plans and documents, a general consistency facilitates regional cooperation and collaboration opportunities. The key documents are identified and described below.

Marquette Plan, Phase I (2005) and Phase II (2008)

The Marquette Plan is a regional plan that creates a comprehensive land use vision for the Lake Michigan drainage basin and a strategy for implementation of that vision. The Marquette Plan established primary goals of increasing public access and developing the urbanized area.

Phase I of the Marquette Plan: The Lakeshore Reinvestment Strategy, was completed in 2005 and addressed public access and redevelopment of the lakeshore from the Illinois state line to the Port of Indiana. Phase II was completed in 2008 and compiled a range of general frameworks and recommendations for land use, green infrastructure at the watershed level, and transportation and access along the lakeshore from the Port of Indiana to the Michigan-Indiana state line.

Marquette Park Lakefront East Master Plan, City of Gary, 2008

The City of Gary recently received funding for the development of a plan for renovation and improvements to Marquette Park, which is located at the far west end of Indiana Dunes National Lakeshore. These capital improvements provide access to and circulation within the park, preserve and strengthen the park's natural features, provide new recreation and education amenities, and restore the park's signature historic facilities. Initial improvements have begun and completion is slated for 2012.

PROPOSED PLAN FOR IMPLEMENTATION

The proposed plan presents the first steps in a long-term process to return Indiana Dunes National Lakeshore to its natural condition.

For instance, various hardened structures have been placed along the shoreline as a result of industrial, federal, and residential development. These structures have historically provided protection for infrastructure from erosion and storm events. However, these structures were not always developed in a way that was beneficial to the entire shoreline. The purpose of this final EIS is to identify and develop strategies to restore the Indiana Dunes National Lakeshore shoreline and its processes. Reestablishment of more natural shoreline processes could eventually allow the current structures within the Indiana Dunes National Lakeshore boundaries along the lakeshore to be removed in the future without endangering the adjacent infrastructure. Note that additional study and compliance would be necessary in order to verify that the current structures could be removed.

ISSUES AND IMPACT TOPICS

PLANNING ISSUES AND IMPACT TOPICS

Climate Change

Climate change refers to any substantial changes in average climatic conditions, such as average temperature, precipitation, or wind. Climate change also refers to considerable changes in climatic variability, such as seasonality or storm frequencies, which last for an extended period of time (decades or longer). The National Park Service recognizes that the main drivers of climate change are outside the control of the agency; climate change is a phenomenon with impacts that cannot be discounted, and which is likely already affecting Indiana Dunes National Lakeshore.

What scientists know is that higher air and water temperatures are already reducing winter ice cover on the Great Lakes, a trend which is expected to accelerate. Scientists believe that Lake Michigan may have some winters with no ice cover in as soon as 10 years. With less ice and more open waters, the lake will have more waves in winter than before, especially during strong storms, increasing erosion threats to park shorelines and structures. Also, because snow and ice cover protect dunes, beaches, and other shoreline features from erosion (by keeping them effectively frozen in place), shorelines are at greater risk of erosion in the future.

The U.S. Geological Survey (USGS), in partnership with the National Park Service, has assessed the possible effects of lake-level declines on the shorelines of three national lakeshores, Indiana Dunes, Sleeping Bear Dunes, and Apostle Islands, much as the U.S. Geological Survey has evaluated possible effects of sea-level rise on some coastal national parks. For these three national lakeshores, the U.S. Geological Survey identified the likelihood of changes in shorelines based on six factors: erosion and accretion (build-up) rates, coastal slopes, relative projected lake-level changes, average wave heights, average ice cover, and geologic stability or susceptibility to changes. The shoreline at Indiana Dunes National Lakeshore has a high or very high potential of shoreline change. The vulnerable areas, mostly in the eastern portions of the lakeshore, include the Central Avenue access point and the beaches below Mount Baldy.

Recent climate change trends in the region of the park include:

- an increase in annual temperatures of 0.25°C per decade
- a progressive advance in the date of the last spring freeze
- increases in autumn precipitation
- doubling of frequencies of heavy rainfall events and an increase in the number of individual rainy days and week-long heavy rainfall events
- increased flooding
- an increase in the number of heat waves and record-high temperatures (Hayhoe *et al.* 2010)

While it is well accepted that climate change is occurring, the rate and severity of impacts at the park is, as yet, undefined. Extreme weather events have historically been documented in the area of the park, specifically in 1998 and 2010. The anticipated increased frequency and intensity of storm events have the potential to exacerbate the loss of sediment along the shoreline, thereby accelerating the accumulation of sediment on accreting shoreline reaches. These likely future conditions add emphasis to the need for an effective, long-term, beach restoration plan.

The issue of climate change is addressed in this plan to recognize its role in the changing environment, and to provide an understanding of its impacts on the park and

the surrounding environment. The potential influences of climate change are described in the "Affected Environment" chapter. While climate change would alter resource conditions within Indiana Dunes National Lakeshore, the type and intensity of these changes is uncertain.

IMPACT TOPICS RETAINED FOR DETAILED ANALYSIS

NPS Director's Order 12: *Conservation Planning, Environmental Impact Analysis, and Decision-making* (2001) lists mandatory topics that must be considered in a NEPA document. The impact topics retained for further analysis and their associated issues presented below are described in more detail in the "Affected Environment" chapter, and impacts on each resource are analyzed in the "Environmental Consequences" chapter. If impact topics (resources) are unaffected by the project or if the impacts to the resources from the project are at a low to very low level, then the topic was eliminated from further analysis, as described under the "Impact Topics Dismissed from Further Consideration" section of this chapter.

Coastal Processes

Sediment Transport Processes. A coastal zone is a dynamic region where land is sculpted and shaped by wave action and currents. The coastal processes of Lake Michigan historically have shaped Indiana Dunes National Lakeshore, and continue to have an effect on the natural features vital to the park, such as beaches and dunes. As the shoreline was modified by human activity over the last century, so too was the effect of the coastal processes on Indiana Dunes National Lakeshore.

Due to the presence of various industrial and navigational structures along Lake Michigan's southern shore, the transport of sediment along the shoreline has been interrupted. This has resulted in areas of accretion, in which the beach appears to be increasing in size as more sediment becomes trapped, and areas of erosion, in which sediment is carried away from the shoreline and transported downdrift. The alternatives presented in this plan describe a variety of approaches to mitigate accretion and erosion.

Dune Formation Processes. Dune development occurs when the lake level remains relatively constant, and sediment is deposited, trapped, and held onshore by vegetation. It is vital that the appropriate quantity of sediment be present in the system to allow for such processes to occur. The alternatives presented allow for additional sediment to be placed into the lake system via a variety of approaches. It is important to evaluate the effectiveness of these alternatives on the development of foredune and dune complexes.

Aquatic Fauna

Native Species. An abundance of benthic communities live and flourish in Lake Michigan. Many of these species use the nearshore environment along Indiana Dunes National Lakeshore during some stage of their lives. As these species are an important resource for the park, the National Park Service has responsibility to protect them to the extent possible. The alternatives presented in this plan would affect these species.

Invasive and Nonnative Species. There are several species of invasive and nonnative benthic organisms and fish known to populate the waters along the southern Lake Michigan shoreline. As these species encroach on the park's waters, the native benthic communities are increasingly at risk of displacement. It is important to assess the potential for the alternatives presented in this plan to introduce, or augment, the spread of the invasive and nonnative species.

Terrestrial Habitat

Native Plant Communities. The National Park Service *Management Policies 2006* requires the National Park Service to protect and conserve native plant and vegetative communities that would be affected by visitors, management actions, and external sources. Actions and alternatives presented in this plan would affect these natural resources. Resource managers are currently tasked with the preservation and restoration of the park's unique natural features.

Invasive and Nonnative Plant Species. The National Park Service defines nonnative and invasive plant species as "those that occur in a given place as a result of direct or indirect, deliberate, or accidental actions by humans." Nonnative invasive plant species are pervasive throughout the park and surrounding lands. Resource managers must contend not only with current threats posed by nonnative invasive plant species but emerging threats as well. Nonnative invasive plant species have already influenced the various reaches and plant communities in the park. Species of special concern, particularly threatened and endangered species, are detrimentally impacted by the encroachment of invasive plants. National Park Service staff are currently monitoring and managing invasive species that pose direct or indirect impacts to species of special concern and critical habitat. It is important to assess the potential for the alternatives presented in this plan to introduce, or augment, the spread of the invasive and nonnative plant species.

Threatened and Endangered Species and Species of Concern

The Endangered Species Act of 1973, as amended, requires an examination of impacts on all federally listed threatened or endangered plant and animal species. It is a responsibility of the park to conform to this legislation, and to extend protection to state-listed threatened, endangered, or rare species.

The park supports a relatively high concentration of biodiversity, and in turn supports many federal and state threatened and endangered species and species of concern. It provides a mosaic of habitats for terrestrial plants and wildlife in a relatively small area. Many of Indiana's plant species of conservation concern are found at the park, including the federal and Indiana threatened Pitcher's thistle (*Cirsium pitcher*). Of concern are the Karner blue butterfly (*Lycaeides melissa samuelis*), Indiana bat (*Myotis sodalis*), piping plover (*Charadrius melodus*), and eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*).

In this final EIS the park assesses whether proposed actions and alternatives have no effect; may affect, but are not likely to adversely affect; or are likely to adversely affect federally threatened or endangered species and candidate species. The park is also using this final EIS to determine if the proposed action and alternatives would destroy or adversely modify critical habitat to the extent that the action would appreciably diminish the value of the critical habitat for the survival and recovery of the species.

Wetlands and Pannes

The aquatic and panne habitats that are contained in the wetland habitats within the project area provide tremendous scientific, educational, and inspirational opportunities. They serve as a transition between Lake Michigan and the beach, and the foredune and dune complexes.

Despite their rarity and relatively small size, pannes hold a vast amount of vascular plant diversity. Many of the plant species found within pannes are located nowhere else in Indiana. They also support numerous insect, mammal, and bird species. These wetlands depend on lake level fluctuation and precipitation for their hydrology, therefore proposed actions and alternatives are reviewed in light of their impacts to the

preservation of function and structure of the aquatic and panne wetland habitats.

Soundscape

The National Park Service *Management Policies 2006* recognize that natural soundscapes are a park resource and call for the National Park Service to preserve, to the extent possible, the natural soundscapes of the parks. It is the responsibility of the park to protect the natural soundscape from degradation due to sounds, which is defined as undesirable human-caused sound or noise. Unnaturally occurring sounds can adversely affect the natural soundscape and other park resources. It can also adversely affect the visitor experience along the shoreline. While Indiana Dunes National Lakeshore is situated within an urban setting with industrial and other facilities adjacent to park boundaries, the soundscape within the project area is dominated not only by human components, but by natural components as well. The alternatives presented in this final EIS may potentially increase noise levels within portions of the project area.

Visitor Experience

The Indiana Dunes National Lakeshore provides a wide range of recreational opportunities and experiences for visitors. Enjoyment of the beaches and dunes along the shoreline are common pastimes for visitors coming to the park. The natural viewshed afforded to those within the park is also a key resource to be considered. As the alternatives presented in this final EIS may result in changes to these experiences.

Park Operations

Park management and operations refers to the current staff available to adequately protect and preserve vital park resources and provide for an effective visitor experience. Shoreline restoration and management activities have the potential to impact staffing levels, staff workloads, and the budget necessary to conduct park operations.

IMPACT TOPICS DISMISSED FROM FURTHER CONSIDERATION

Due to the scope of this project, several impact topics have been considered and ultimately dismissed from further discussion because of the low to very low level of impacts.

Air Quality

Since 1988, the EPA, in coordination with state and federal land management agencies, has conducted monitoring of air pollution and visibility at a number of national parks and wilderness areas across the country. The park is located within a class II air quality area because of the heavy industrialization of northwest Indiana. Class I areas have pristine air quality. Class II areas have higher incremental air quality limits than class I areas due to less pristine background air quality, and are allowed moderate air quality deteriorations. The actions associated with the alternatives presented in this plan would not violate air quality standards or result in a cumulative net increase of criteria pollutants under federal or state ambient air quality standards. Emissions from actions in the alternatives would result in negligible effects on air quality, and Indiana Dunes National Lakeshore's class II air quality would be unaffected. This topic has been dismissed from further analysis because there would only be negligible effects on air quality.

Carbon Footprint

For the purpose of this planning effort "carbon footprint" is defined as the sum of all emissions of carbon dioxide and other greenhouse gases (GHG) (e.g., methane and ozone) that would result from implementation of the proposed alternatives.

The proposed action alternatives vary widely in terms of use of vehicles involved in the project and as such the focus of the GHG emissions analysis associated with the alternatives in this final EIS is on emissions from land- and water-based vehicles (heavy-duty trucks and barges, respectively). Thus, the most energy intensive alternatives were evaluated as shown in Table 1-1: Annual Greenhouse Gas Emissions, for annual GHG emissions using emission factors and calculation methodologies recommended by the EPA Climate Leaders in *GHG Inventory Protocol Core Module Guidance, Direct Emissions from Mobile Combustion Sources* (EPA 2008) for estimating direct GHG emissions resulting from mobile sources. The two most energy intensive alternatives involve 50 to 80 heavy-duty diesel trucks entering the park each day for a period of up to four months during an annual cycle, or up to 18 months during a five-year cycle. The highest expected annual GHG emissions from mobile sources for these alternatives is approximately 3,500 metric tons of carbon dioxide equivalent ($mtCO_2e$) per year. Other alternatives discussed in this document involve the use of a barge and minimal construction equipment for periods of six or eight weeks. As barges are more efficient at moving dry goods on a ton-per-mile basis, emissions for the remaining alternatives are expected to be much lower.

The 3,500 $mtCO_2e$ GHG emission level is well below the CEQ guidance level of 25,000 $mtCO_2e$ recommended for developing further detailed analysis. To provide a context for these numbers, the total GHG emissions for Indiana Dunes National Lakeshore in 2008 were approximately 5,220 $mtCO_2e$; GHG emissions for the U.S. Steel Midwest Plant (adjacent to the park) in 2010 were 317,627 $mtCO_2e$; and the GHG emissions for the state of Michigan in 2002 were 62.5 million $mtCO_2e$ (no GHG inventory has been conducted for the state of Indiana). Thus, the greatest potential GHG emissions from the project, when compared to park baseline emissions in 2008, larger regional and state emissions, and CEQ guidance, are minimal. Therefore, the actions associated with the alternatives presented in this final EIS are unlikely to produce more than minor GHG emissions. This topic has been dismissed from further analysis because there would only be minor or less effects from GHG emissions.

TABLE 1-1. ANNUAL GREENHOUSE GAS EMISSIONS

Source	Annual GHG Emissions (Million Metric Tons CO_2e)	Year
Alternative B–5	0.0035	N/A
Indiana Dunes National Lakeshore	0.0052	2008
CEQ Guidance	0.0250	N/A
U.S. Steel Midwest Plant (adjacent to the park)	0.3176	2010
State of Michigan	62.5	2002

SOURCES: Mid–Atlantic Diesel Collaborative 2010; EPA 2008

Cultural Resources

All projects with the potential to affect cultural resources would be carried out consistent with Section 106 of the National Historic Preservation Act (NHPA), as amended, to ensure that the effects would be adequately addressed. Reasonable measures would be taken to avoid, minimize, or mitigate adverse effects in consultation with the Indiana state historic preservation officer (SHPO), Tribal historic preservation officers, and, as necessary, the Advisory Council on Historic Preservation, and other interested parties. In addition to adhering to the legal and policy requirements for cultural resource protection and preservation, the National Park Service would also undertake mitigation measures listed in the "Mitigation Measures Common To All Action Alternatives" section of "The Alternatives" chapter to further protect the park's resources. Per Section 106 of NHPA, the National Park Service would seek a determination of "no adverse effects" to historic or archeological resources from the Indiana SHPO.

Historic Resources. There are several historic structures within the park including five houses located along Lake Front Drive in Beverly Shores that were built for the 1933 Century of Progress exposition and the three houses known as the Solomon Enclave. There is one identified cultural landscape, the Solomon Enclave, located on Lake Front Drive in Beverly Shores. These resources are not located within the project area that is the focus of this plan. Historic structures and cultural landscapes at the park would not be impacted by the actions associated with the proposed alternatives, therefore historic structures and cultural landscapes have been dismissed from further analysis.

Submerged Resources. There are several historic shipwrecks offshore from the park, including one or more along the shoreline reaches under analysis for shoreline actions. A Coastal Historic and Cultural Resources Study of the Lake Michigan Watershed was conducted in 2000 for the Indiana Department of Natural Resources (IDNR) Division of Historic Preservation and Archaeology. The study was performed to assess the status of existing plans and current resources for public recreation access, including offshore shipwrecks, and to make recommendations on feasibility, management need, and demand on resources for recreation access to underwater resources in Lake Michigan. Although the Indiana territorial waters include only 225 square miles of Lake Michigan, previous investigations by the IDNR identified the potential for 50 historic vessels. A total of 14 known shipwrecks are listed in the Indiana Maritime Cultural Resource Inventory. Assessment and surveys indicate two of these sites, the Muskegon and the J.D. Marshall, have attributes for potential enhanced recreational value. The J.D. Marshall is located under 30 to 35 feet of water more than 3,000 feet offshore from Indiana Dunes National Lakeshore, while the Muskegon is located under 25 to 30 feet of water more than 1,000 feet offshore from Mount Baldy along the shoreline at Indiana Dunes National Lakeshore (The Office of Underwater Science 2000).

Shoreline restoration activities under analysis in this plan would be closer to the shoreline than most of the historic shipwrecks. A series of mitigation measures would be used to protect submerged resources during nourishment activities associated with the proposed alternatives. These measures would include the use of protective fences and buoys, and signs.

With protective measures in place to preserve submerged historic shipwrecks, these submerged resources would be minimally impacted by the actions associated with the proposed alternatives. Therefore, submerged historic resources have been dismissed from further analysis.

Archeological Resources. There could be archeological resources within the project area at Indiana Dunes National Lakeshore that are currently unknown, and which could become known prior to any beach nourishment activities that may result from this plan. In such instances a series of protection measures would be used to protect archeological resources. These measures would include the use of protective fences and signs. This topic has been dismissed from further analysis because these measures would result in no effect to archeological resources.

Environmental Justice

Presidential Executive Order 12898, "General Actions to Address Environmental Justice in Minority Populations and Low-income Populations," requires all federal agencies to incorporate environmental justice into their policies by identifying and addressing the disproportionately high and/or adverse human health or environmental effects of their programs on minorities and low-income populations and communities. The alternatives under consideration in this plan would have no appreciable impact on minorities or low-income populations or communities. The actions in the alternatives would not result in identifiable adverse human health effects, nor would they substantially

alter the physical and social structure of the nearby communities. This topic has been dismissed from further analysis because actions associated with the proposed alternatives would have no adverse affect on minority or low-income populations.

Human Health Concerns

Both human and natural pathways that introduce and spread pathogens and other contaminants dangerous to human health exist at Lake Michigan. With increased visitor access to and use of Indiana Dunes National Lakeshore comes an increased risk of exposure to *Escherichia coli* (*E. coli*) and other pathogens. Dredging and sediment disturbance have the potential to release harmful bacteria such as fecal indicator bacteria (*E. coli*) and *Clostridium botulinum*. Berms and permanent bypass systems could attract exotic species (i.e., zebra mussels [*Dreissena polymorpha*] and quagga mussels [*Dreissena rostriformis bugensis*]) which may increase the risk of exposure to botulinum toxin. Botulinum toxin is a metabolic waste produced under anaerobic conditions by *Clostridium botulinum*, a bacteria that can be found in the tissue of bivalves (e.g., mussels). The risk of botulinum toxin exposure would be diminished as the exotic species would eventually be covered with sediment. It is outside the scope of this plan to control potential pathogens or similar impacts to water quality. To maintain compliance with the Clean Water Act of 1972, the National Park Service cannot knowingly implement actions that would have a detrimental effect on water quality. Therefore, while the alternatives presented in this plan do not propose to remove human health concerns from the waters of Lake Michigan, the proposed project would not be expected to adversely affect Lake Michigan water quality and/or introduce harmful pathogens.

Required permitting conducted prior to dredging, sediment placement, and berm or bypass construction activities would identify mitigation required to protect against human health concerns. Appropriate measures would be taken during the final planning and permitting stages to ensure that the actions conducted along the shoreline comply with the standards upheld by the National Park Service. Actions such as fencing, signs, and visitor education would be used to reduce visitor exposure to pathogens and contaminants. With required mitigation in place to protect human health from harmful bacteria released from dredging and sediment placement activities, there would be negligible impacts to human health. This topic has been dismissed from further analysis because actions associated with the proposed alternatives would have negligible effects on human health.

Socioeconomic Resources

NPS Director's Order 12: *Conservation Planning, Environmental Impact Analysis, and Decision-making* requires consideration of potential direct and indirect impacts to the local economy, including impacts to neighboring businesses in the general project vicinity. The No-action alternative, the preferred alternative, and the other action alternatives considered as part of this plan would not change local and regional land use, nor would they appreciably impact local businesses or other agencies. This resource has been dismissed from further analysis because none of the actions associated with the proposed alternatives has the potential to impact the socioeconomic environment of the area.

Water Quality

Indiana Dunes National Lakeshore, because of the fragmented nature of the lakeshore, the beach, dune complexes, and terrestrial habitats along the shoreline, is impacted by both permitted and nonpoint discharges into Lake Michigan which can directly affect park aquatic resources. It is beyond the scope of this plan to address these discharges into Lake Michigan. The National Park Service cannot

knowingly implement actions that would have a detrimental effect on water quality. However, the alternatives in this plan have a very low probability of improving or adversely affecting the water quality of Lake Michigan. Any action taken as part of the implementation of this plan would be subject to any and all appropriate measures to comply with water quality standards. Because the probability of effects to water quality from actions associated with the proposed alternatives is very low, water quality has been dismissed from further analysis.

CHAPTER 2
The Alternatives

INTRODUCTION

In general, the shoreline at Indiana Dunes National Lakeshore naturally functions as a dynamic environment. A dynamically stable shoreline is one that has experienced either minor or no positioning changes over a long period of time (i.e., 50 years or greater). Wave action maintains the beach profile by supplying and collecting sediment along the shoreline. Wind action and major storm events work in conjunction with lake processes to create the dune complex. As dunal succession is wind driven, the presence or absence of vegetation on the dune face can influence the speed at which the dunes move. Vegetation established on a dune reduces the amount of sediment blown away by wind action, thus slowing down the movement of the dune. With the introduction of urban development along the lakeshore came disruptions to the intricate coastal processes of Lake Michigan's southern shoreline. This *Shoreline Restoration and Management Plan / Final Environmental Impact Statement* (EIS) addresses the restoration of certain natural processes within the context of a modified system. The proposed alternatives represent the range of possible actions the park is considering, consistent with NPS policy, Indiana Dunes National Lakeshore's purpose, and the interest of the public. The alternatives have been designed to be implemented at specific areas of the shoreline during approximately the next 20 years. Full implementation would require cooperation and coordination between local, state, and federal agencies. In addition, the plan anticipates that these alternative actions would be implemented in all reaches of the project area at the same time, rather than only in one reach at one time.

As discussed in detail below, alternative A is a continuation of current management practices and is included as the baseline for comparing the consequences of each alternative. Alternatives B through D represent variations of beach nourishment activities. Alternatives B-1 and B-5 include beach nourishment using material trucked to the shoreline from an upland source in one- and five-year frequencies, respectively. Beach nourishment via dredged materials in one- and five-year frequencies is proposed under alternatives C-1 and C-5, respectively. Alternative D outlines nourishment activities achieved through a permanent bypass system. The use of a submerged cobble berm in conjunction with annual nourishment is discussed as alternative E. Finally, a hybrid of alternatives C-1, B-1, and E, which includes annual beach nourishment with a mix of small natural stone, dredged sediment, and coarse upland material at the shoreline, is discussed as alternative F.

It is important to include terrestrial management practices when discussing shoreline restoration alternatives, as terrestrial and aquatic habitats are directly affected by similar processes. For example, dune-stabilizing vegetation historically present along the beach has been trampled, thus disrupting the delicate balance of dune formation processes. As the park is a popular destination for millions of people, the impacts of human actions on the natural resources of the park are ever present. The purpose of terrestrial management actions in the park is resource protection. Actions that could introduce nonnative invasive species are constantly present as visitors arrive by foot, in vehicles, and by train and bring pets and materials into the park. Habitat for endangered and threatened species and species of concern becomes more at risk as recreational uses of the park for activities such as hiking, cross-country skiing, snowshoeing, and horseback riding have extended further into the fall and winter seasons.

PROJECT AREA DEFINITION

For the purpose of this plan / final EIS, the shoreline has been divided into four reaches based on sediment accretion and erosion rates of the shoreline. The project area consists of reaches 1 through 4, numbered in an east-to-west direction. The shoreline within the park is not contiguous, but rather is interrupted by industrial and other properties. These reaches include industrial and navigational structures, as well as portions of the shoreline armored with revetment walls and other hardened structures. The alternatives developed for this plan were developed to benefit the entire shoreline as opposed to a single land owner. As depicted on Figure 2-1: Shoreline Reaches, the designated reaches encompass the following shoreline areas:

- reach 1, Crescent Dune to the east end of Lake Front Drive
- reach 2, east end of Lake Front Drive to Willow Lane
- reach 3, Willow Lane to Beach Lane
- reach 4, Beach Lane to the Gary-U.S. Steel East Breakwater

The direction of net transport of sediment moving along the park shoreline is from east-to-west. There are three primary man-made structures in and around the project area that constitute barriers to littoral drift and affect the park. These structures are federal and industrial harbors that impact the natural sediment transport by disrupting the natural sediment flow and generally result in accretion to the east (updrift) and erosion to the west (downdrift).

The three harbors adjacent to, and within, the project area are:

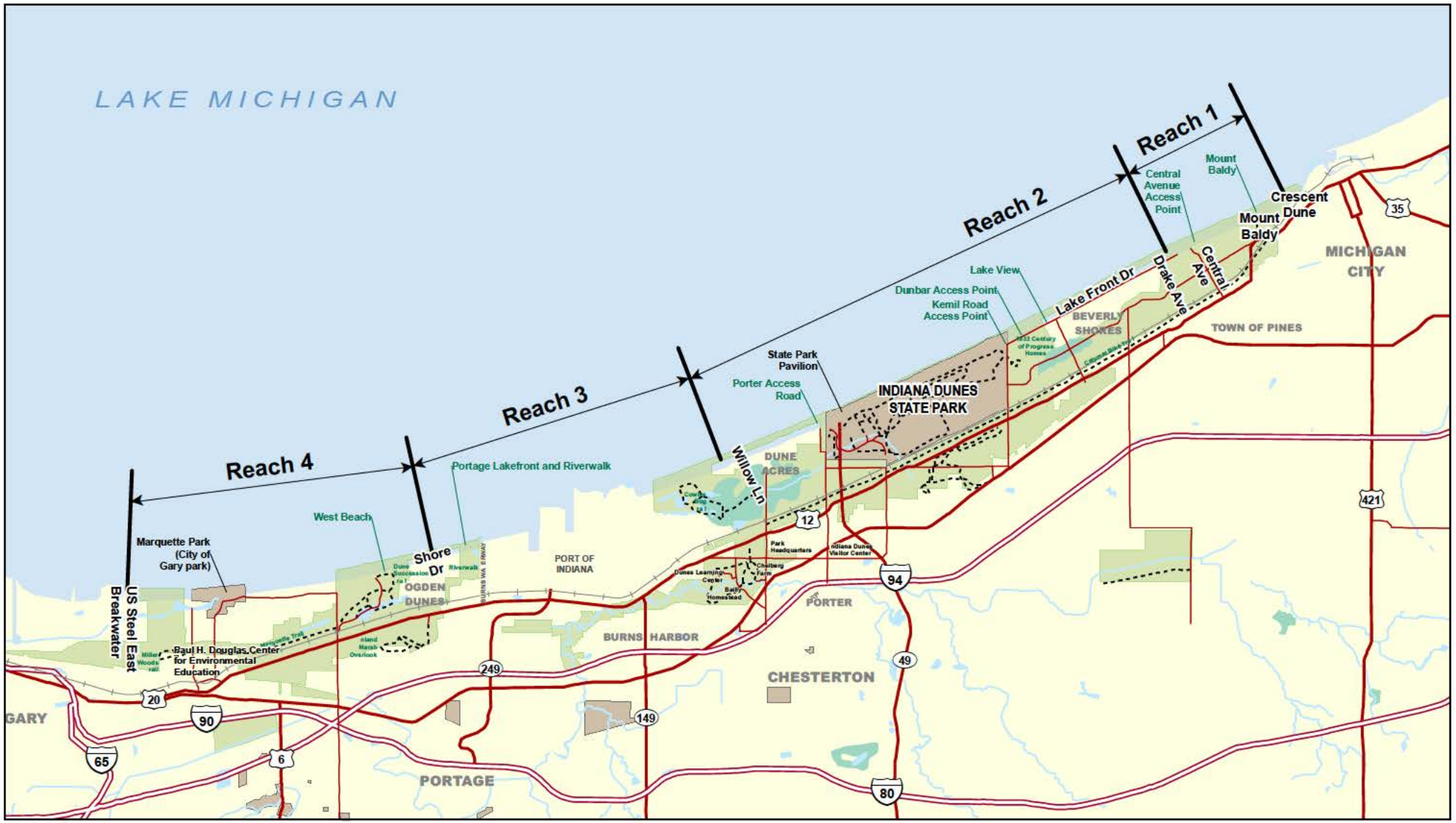
- to the east, the Michigan City Harbor (initial construction in 1834, harbor completed in the early 1900s)
- the Burns International Harbor (constructed in the late 1960s)
- to the west, the Gary-U.S. Steel Harbor (constructed in the early 1900s)

The preliminary analysis to estimate the total volume of sediment trapped by development was based on detailed aerial photographs from representative pre-harbor conditions to present. In addition, the analysis considered quantities dredged and the volume of sediment bypassing the shoreline because of the harbor structures to calculate (for reach 1) and estimate (for reach 3) sediment volume trapped. Based on preliminary calculations, the total quantities of accreted sediment (from pre-harbor conditions to present) on the east adjacent to the harbors are:

- Michigan City Harbor has approximately 28.2 million cubic meters (m^3) (36.8 million cubic yard [yd^3]) of accreted sediment. This quantity does not include the volume of sediment dredged in the navigation channel and artificially bypassed.
- Burns International Harbor has approximately 3.5 million m^3 (4.6 million yd^3) of accreted sediment. This quantity does not include sediment dredged and artificially bypassed, which totals 1.7 million m^3 (2.2 million yd^3).
- Gary-U.S. Steel has approximately 2.2 million m^3 (2.9 million yd^3) of accreted sediment. This quantity is based on the current shoreline orientation defined by the confined disposal facility constructed post-1950.

The restoration alternatives set forth are particularly relevant to reaches 1 and 3 along the park shoreline (see Figure 2-1: Shoreline Reaches). Reach 1, located at the easternmost end of the park shoreline, is an actively eroding area, particularly at the base of Mount Baldy. As the natural net sediment transport extends from east-to-west in the project area, the Michigan City Harbor structure updrift of the project area interrupts the littoral drift, creating an accreting beach fillet on the east side of the harbor, and erosion within the area of Mount Baldy (which is downdrift). Reach 3 denotes the stretch of shoreline in the central

portion of the project area and includes a shipping harbor. Harbor structures associated with this property extend into Lake Michigan, creating a sediment accretion area to the east, and an erosion area at Portage Lakefront and Riverwalk. Each of these areas exhibit the extreme effects of interruption to the littoral drift along the park shoreline; therefore, it is important to focus restoration efforts in these areas, provide beach nourishment material, and provide conditions for distribution of the nourishment material via natural lake processes to the extent possible. This plan assumes that these restoration efforts would be implemented in both reaches 1 and 3 at the same time in order to best mimic natural dynamics.



Legend

- Indiana Dunes National Lakeshore
- State and Local Parkland

N

6,000 0 6,000 Feet

1 inch = 12,000 feet

FIGURE 2-1
SHORELINE REACHES
Indiana Dunes National Lakeshore
Shoreline Restoration and Management
Plan / Environmental Impact Statement
National Park Service / U.S. Department of the Interior
March 2012

ALTERNATIVES DEVELOPMENT PROCESS

TECHNICAL ANALYSIS

In September and October 2010, NPS park staff and consultant engineers and scientists observed and documented the existing shoreline conditions. Photographs and limited measurements were taken. In addition, a review of various reports and other documents focused on local conditions of Lake Michigan's southern shoreline was conducted to gather information on coastal processes, shoreline evolution, sediment sampling and analysis, dredging, and beach nourishment history. Additional information regarding this literature review is provided in Appendix C: Technical References.

The technical analyses completed for the project area are described below.

Shoreline Evolution

Analysis of the shoreline from 1951–1952 to 2010 was conducted to quantify long-term changes in shoreline position as depicted on Figure 2-2: Shoreline Comparison. The 1950 aerial year was chosen as representative of the pre-harbor conditions and represents the baseline shoreline "natural" conditions. This analysis considered the dredging and beach nourishment events in the project area that took place during this timeframe. The shoreline initially was divided into reaches based on areas of general accretion, erosion, and dynamically stable areas. The long-term highest erosion rates along the lakeshore were calculated at Mount Baldy (4.5 feet per year [ft./yr.]), and at Portage Lakefront and Riverwalk (2.7 ft./yr.). The highest accretion rates were identified at the Burns International Harbor East Fillet Beach (7.6 ft./yr.) and at the Gary-U.S. Steel Harbor East Fillet Beach (5.1 ft./yr.). These areas are depicted in Figure 2-3: Shoreline Erosion and Accretion Zones. Additional detailed information is provided in Appendix C: Technical References.

Water Level and Wave Climate

A probability analysis of recorded water levels and computer modeling of the Lake Michigan wave climate was conducted. This analysis provided useful data for formulating conceptual design alternatives and other details such as the required beach fill materials, slope and extents, and location/water depths for placement. The stability of beach nourishment would be directly affected over the plan's life by the water levels and storm events. The 100-year storm event was selected as the conceptual design condition for the shoreline improvements, along with a lake level of 584.7 feet (+7.2 feet International Great Lakes Low Water Datum IGLD85). Wave height is controlled by water depth. For example, a maximum wave height of 10.7 feet at a reference 6-foot water depth (at Low Water Datum, or total water depth of 13.2 feet at design condition) was calculated.

Longshore Sediment Transport

Waves breaking along the shoreline and the wave-induced currents generate movement of beach sediment known as longshore transport or littoral transport. Sediment movement along the shoreline is referred to as littoral drift and is expressed in yd^3 per year. Longshore sediment transport primarily consists of sediment suspended within the water column. Based on the variability of wind and wave directions, sediment transport is often reported as a net volume indicating the sum of all transport values directions (positive and negative). Longshore transport can be interrupted/impacted by coastal structures extending into the lake, which can block sediment transport.

A two-dimensional numerical model (COSMOS) was used to calculate sediment transport rates along the shoreline at selected intervals of 1.25 miles for current and historic

pre-harbor conditions. The beach profiles extended out to a depth of approximately 15 meters (or approximately 49 feet) below chart low water datum (LWD). It was determined that the net longshore sediment transport gradually decreases from New Buffalo (200,000 yd^3 updrift of Michigan City) east to the Burns International Harbor. The longshore sediment transport rate is estimated at less than 30,000 yd^3 per year near the Gary-U.S. Steel Harbor.

Sediment Budget at Mount Baldy

This analysis used the findings of a previous investigation performed for the Michigan City area (Baird 2004). A hydrodynamic and sediment transport analysis was completed to improve the understanding of the hydrodynamics at the Michigan City Harbor, patterns of sediment transport, bypassing rates around the harbor structures, and the role the Michigan City Harbor plays on the Mount Baldy sediment budget. A two-dimensional hydrodynamic and sediment transport model (HYDROSED) was applied to the analysis of the existing wave conditions, nearshore currents, and sediment transport rates at Michigan City. The model was then used to quantify the sedimentation and bypassing rates in the area. With the combined results of the COSMOS and HYDROSED modeling, a sediment budget assessment was completed. The sediment budget accounts for all sediment sinks, sources, inputs, and outputs of sediment within a confined cell or boundary. This approach provides the framework to describe and understand long-term morphological changes, such as erosion and sedimentation rates. The annual long-term average trucked quantities of beach nourishment at Mount Baldy and quantities of Michigan City dredged and mechanically bypassed material were included in the sediment budget. It was determined that the area around Mount Baldy has a calculated sediment budget deficit of 105,000 yd^3 of sediment per year due to the sediment trapped at Michigan City.

Light Detection and Ranging (LIDAR)

Based on existing (2010) detailed LIDAR bathymetry (or underwater survey data) used for this study, the data coverage is good overall. However, the topographic (land-based data) is scarce in reach 3. For reach 3, one-foot contours were interpolated and an average beach slope was estimated between the 570.0 (-7.5 feet LWD) and 580.0 (+2.5 feet LWD).

FORMULATION OF THE ALTERNATIVES

The alternatives, developed as a result of the technical analysis, focus on what restoration metrics or desired conditions should be achieved. Alternatives for managing Indiana Dunes National Lakeshore were developed by identifying different ways to address the planning issues identified in the "Purpose and Need for Action" chapter in context with the park's purpose and significance. In developing this range of alternatives, the National Park Service carefully considered the national lakeshore's purpose and significance as well as the national lakeshore's enabling legislation.

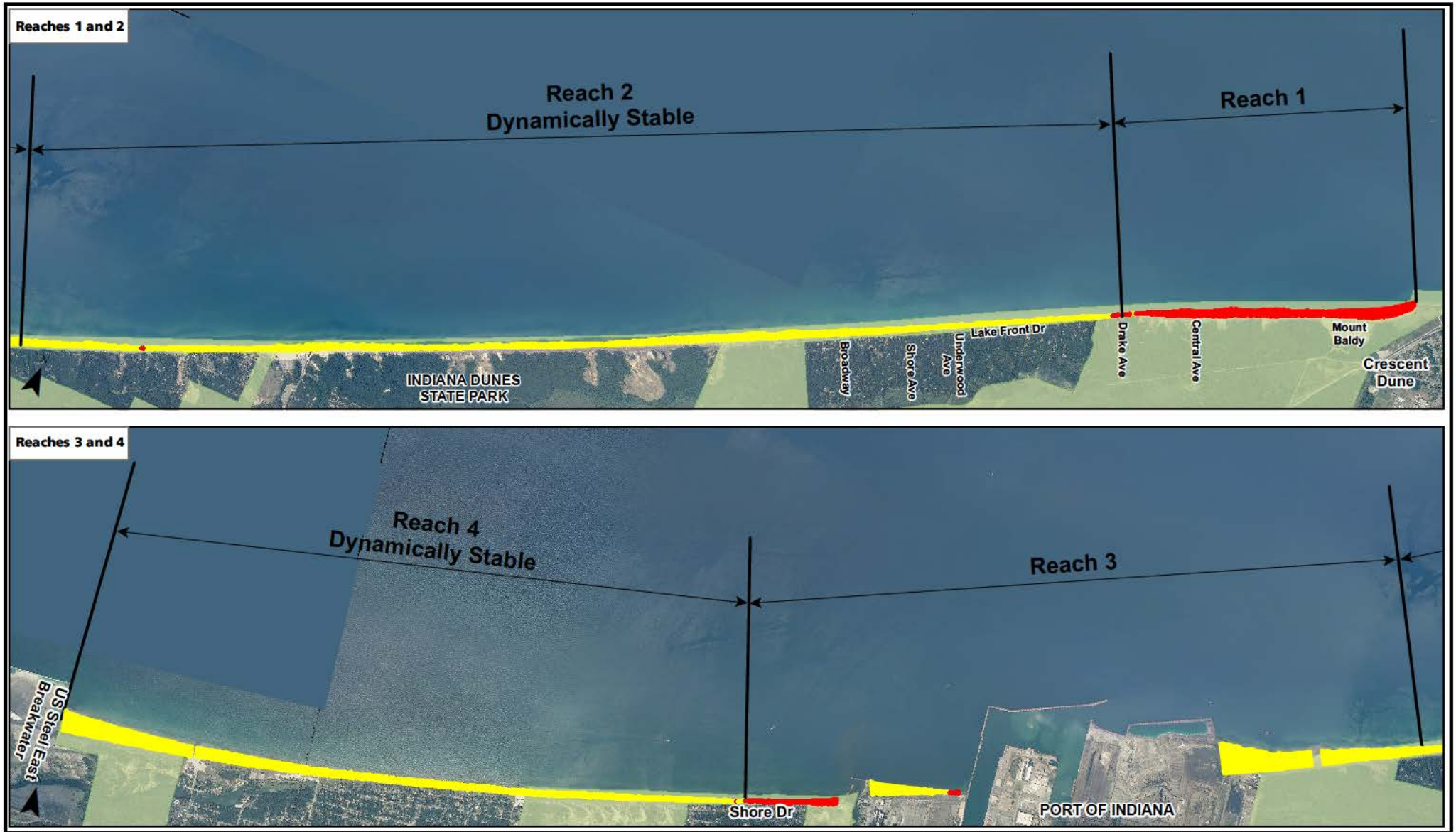
NEEDED FUTURE STUDIES AND PLANS

Once this plan is completed, many of the nourishment activities proposed under the alternatives could be implemented without further compliance or study. Other more detailed studies and plans could be needed before some specific actions would be implemented, such as specific techniques for mixing a full range of nourishment materials on-site.

Additional environmental compliance (National Environmental Policy Act of 1969, as amended [NEPA], National Historic Preservation Act, as amended [NHPA], and other relevant laws and policies) and public involvement would also be conducted, as required.

FIGURE 2-2
SHORELINE COMPARISON
Indiana Dunes National Lakeshore
Shoreline Restoration and Management Plan / Environmental Impact Statement

National Park Service / U.S. Department of the Interior
March 2012



Legend

Indiana Dunes National Lakeshore

Shoreline Change Trend

Accretion

Erosion

0.5 0 0.5

Miles

1 inch = 1 miles

FIGURE 2-3
SHORELINE EROSION AND ACCRETION ZONES

Indiana Dunes National Lakeshore
Shoreline Restoration and Management
Plan / Environmental Impact Statement

National Park Service / U.S. Department of the Interior
March 2012

CHOOSING BY ADVANTAGE PROCESS

Selection of the NPS preferred alternative involved evaluating the alternatives using an objective analysis process called Choosing by Advantages. This process included a three-day workshop in which 17 participants, including a representative from the Chicago District U.S. Army COE, consultant engineers and scientists, and NPS park staff representing a variety of divisions in the park, worked together to identify the preferred alternative. Through this process the planning team identified and compared the relative advantages of each alternative according to a set of factors. These factors were selected based on the key differences or decision points for each alternative in relation to fulfilling the purpose of the plan, while addressing the planning issues identified in the "Purpose and Need for Action" chapter. These factors included the following:

- factor 1 – addresses attributes of beach nourishment
- factor 2 – provides for protection of eroding areas
- factor 3 – provides for promoting foredune development
- factor 4 – provides habitat opportunities for desired native species
- factor 5 – discourages establishment of nonnative/invasive species
- factor 6 – maintains and enhances the shoreline's recreation beach
- factor 7 – provides for restoration of the shoreline to a condition that mimics natural conditions

In addition to the factors identified above, the planning team identified the following assumptions regarding the alternatives evaluated:

- the nourishment material would meet NPS requirements to the extent possible
- work would be scheduled to minimize impacts on visitors and park resources
- the proposed plan would be the beginning of a longer term process to return Indiana Dunes National Lakeshore to its natural condition as described in the "Proposed Plan for Implementation" section
- appropriate safety measures for the beach nourishment activities and work site(s) would be articulated in required permits

Decisions made during the Choosing by Advantages process were based on the importance of advantages between the alternatives. This involved identifying the attributes or characteristics of each alternative relative to the factors described above, determining the advantages for each alternative for each factor, and then assessing the importance of each advantage. The relationship between the advantages and costs of each alternative were also considered. This information was used to identify the alternative that provides the National Park Service and the public the greatest advantage for the most reasonable cost.

The results of the Choosing by Advantages process identified alternatives that provide the best combination of strategies to protect the national lakeshore's unique resources and visitor experience while improving the operational sustainability within each reach. These alternatives also offer advantages to the neighboring communities. Overall, the preferred alternatives originally selected for the plan / draft EIS provide the National Park Service with the greatest overall benefits for each identified factor at the most reasonable cost.

However, in response to public concerns expressed during the review of the plan / draft EIS, the preferred alternatives were revised in order to satisfy public concern and still achieve the project goals.

SELECTION OF ALTERNATIVES FOR IMPLEMENTATION

Nourishment is the single-most important feature of this plan to restore a more natural sediment transport regime. The planning team considered that the two most likely sources for sediment that would reasonably be available for nourishment activities were upland sources and dredged sources. In terms of the action alternatives needed to address the deficit of sediment in the sediment transport regime, the sediments used for nourishment of the shoreline are required to match the conditions of the existing beach. These alternatives describe ideal conditions where the correct mix of sediment can be found from a single source to match existing beach conditions. In reality, there would be a need to mix sediment sources to achieve the correct sediment composition. This means that, should it become necessary to mix nourishment sources (upland and dredged) to meet the desired beach conditions, the National Park Service would do so without further analysis.

In identifying the preferred alternative for reaches 1 and 2, the one-year nourishment regime along with the submerged cobble berm was identified as providing the greatest advantage during alternative development. because the berm would act both as a temporary buffer and as a means of replacing a missing component of the nearshore habitat in reach 1. The annual nourishment component of that alternative addressed the need to restore the transport of sediment. The remaining action alternatives analyzed within this final EIS, each providing nourishment, were determined to perform equally in terms of providing value to the restoration process. However, public comment on the plan / draft EIS (July 2012) was extensive and ranged from support for the goals of the project to concern about a number of aspects of the draft alternative. The public was generally supportive of beach nourishment, but there was consistent, negative response to the proposed cobble berm in alternative E (preferred alternative in the draft EIS). While the potential impacts of the submerged cobble berm were addressed in the draft EIS, the public concern was such that the National Park Service chose to review the array of alternatives to determine the feasibility of both satisfying public concern and achieving the project goals through the development of a new hybrid alternative.

The criteria critical to the selection of the submerged cobble berm as the draft preferred alternative focused on the restoration of native materials (sediment, gravel, rock) to the shoreline and not necessarily on the method of placement (i.e., creating a submerged berm). The new hybrid alternative would provide the identical materials to the shoreline only through a direct placement process. The majority of material used for beach nourishment would be obtained from fine and medium grained sediments that can be hydraulically dredged from areas of accretion (as in alternative C-1). The additional gravel and rock component would be accomplished by also implementing a portion of alternative B-1. Rather than using the inland mined source to provide the entire spectrum of beach nourishment, only the coarse component (gravels and rock), proposed by alternative E, would be hauled to the beach and mixed on-site with the hydraulically dredged sands. Thus, the new hybrid alternative F, which incorporates the benefit of the gravel and rock materials from alternative E, the inland mined and hauled sources outlined in alternative B-1, with the hydraulically dredged sands outlined in alternative C-1.

In selecting the preferred alternative for reaches 3 and 4, the five-year nourishment regime provided the greatest advantage during initial alternative development because the five-year nourishment addressed the need to restore the transport of sediment and was the most cost efficient. The remaining action alternatives analyzed within the final EIS provided similar advantages during alternative development with the exception of cost. Costs would initially be greater under the five-year

alternative but would ultimately be lower over the life of the alternative.

However, as a result of comments received during public review of the plan / draft EIS expressing concern about the large volume of nourishment material associated with the five-year nourishment regime, the preferred alternative for reaches 3 and 4 was changed to annual beach nourishment.

RESTORATION METRICS AND DESIRED CONDITIONS

The alternatives were designed to balance sediment movement along the shoreline with the following:

- protect eroding areas of the shoreline
- provide habitat opportunities
- allow for natural processes to continue
- restore the shoreline in a cost-effective manner

To determine if the goals of the plan have been achieved, the National Park Service identified desired conditions. The desired conditions articulate the ideal conditions the National Park Service is striving to attain. Table 2-1: Desired Conditions, presents the restoration desired condition by resource for this plan.

TABLE 2-1. DESIRED CONDITIONS

Resource	Desired Conditions
Sediment Transport Process	Sediment supply would be increased to a quantity that would fulfill the calculated/estimated sediment budget deficit. This process would be implemented in a manner that mimics natural processes to the greatest extent possible. Sediment transport is important for the sustainability of the shoreline, foredunes and dunes. The long-term erosion of the shoreline's current position would be prevented.
Dune Formation	Sediment supply would be sufficient for foredune creation along the Indiana Dunes National Lakeshore. The additional sediment placed on the beach would allow wind action to deposit material on the beach, creating foredunes.
Aquatic Fauna	The National Park Service *Management Policies 2006* requires that the natural resources within the park be managed to a high degree of ecological integrity. Actions taken to improve sediment transport along the shoreline would encourage desired native species to establish in the nearshore environment in healthy populations. An increase in the nonnative species populations relative to current assemblages would result in the need for corrective actions to be taken.
Terrestrial Habitat	A biologically diverse terrestrial vegetation community is a natural resource of vital importance to Indiana Dunes National Lakeshore. Several sensitive habitats within the project area include rare plant varieties. Native species would establish in communities, and would be enjoyed by the public without being disturbed or damaged such as by trampling. An increase in the nonnative species populations relative to current quantities would result in the need for corrective actions to be taken.

TABLE 2-1. DESIRED CONDITIONS

Resource	Desired Conditions
Threatened and Endangered Species and Species of Concern	Indiana Dunes National Lakeshore is home to several threatened and endangered species and species of concern. It is the policy of the National Park Service to protect threatened and endangered species and species of concern, to reduce the risk of injury or harm to habitats colonized by these species, and to provide suitable habitat and refugia. There would be a continued presence and establishment of threatened and endangered species and species of concern within the park. By reclaiming and providing habitat, the existence of special status species within the park would be enhanced.
Wetlands and Pannes	The wetlands and pannes in the park are rare habitats characterized by a high floristic quality that would be maintained and protected. Continued inventory of wetlands and pannes within the project area would allow park managers to determine to what extent these habitats are being protected. Threats to wetlands and pannes would be identified and effectively managed to encourage the establishment of native species.
Soundscape	Natural soundscapes would be preserved and noise of the surrounding urban development would be minimized to the extent practicable. Many areas along the shoreline of Indiana Dunes National Lakeshore provide an opportunity to experience the park with less prevalent industrial and vehicular sounds. Management measures would be implemented to ensure that the desired soundscape is maintained to the greatest extent possible.
Visitor Experience	Visitors could experience park opportunities consistent with the purpose and significance of Indiana Dunes National Lakeshore. Visitor experience would include the education that provides for optimal visitor enjoyment while protecting the natural resources of the park. Visitors would actively contribute to the betterment of shoreline health through appropriate use and behavior. The public would be educated in the reasons for use management to encourage stewardship. The visual quality of the natural viewshed and landscapes would provide park visitors with an immediate and lasting experience that conveys the character of Indiana Dunes National Lakeshore. Key vistas would be identified and preserved.

APPROACHES TO ADAPTIVE MANAGEMENT

Each of the alternatives for the shoreline and beach complex and the proposed actions for the foredune and dune complex employs an adaptive element involving monitoring and evaluation. This means that although each alternative includes predictions as to the effectiveness of the restoration actions, ultimately some of those actions may change as knowledge is gained through implementation of the preferred alternatives. The National Park Service would monitor and evaluate the shoreline's response to the implementation of the preferred alternative and would periodically inform the public about shoreline management via newsletters or public meetings. These updates would include any changes or deviations in the management actions prompted by the results of monitoring and evaluation.

Because the issues addressed in this plan are complex, management of the proposed actions would likely require some adaptation as the preferred alternatives are implemented. For example, the beach nourishment program would be evaluated to determine its effectiveness over the course of the plan's lifespan. Monitoring of the shoreline profile and nearshore habitats would be conducted to ensure that park resources are not negatively

impacted by the implementation of the preferred alternatives, and that the beach nourishment activities are meeting the goals of the plan. This adaptive process would allow the National Park Service to evaluate the relative success of the actions and to suggest changes in the amount and/or frequency of beach nourishment to ensure that the integrity of the shoreline system is preserved and that the effects of the beach nourishment are positive, while allowing for resource protection and a continued high quality visitor experience.

MITIGATION MEASURES COMMON TO ALL ACTION ALTERNATIVES

National Park Service staff routinely evaluate and implement mitigation measures when conditions occur that would adversely affect the sustainability of NPS resources. Mitigation measures are the practicable and appropriate approaches that would be used under the action alternatives to avoid and/or minimize harm to park natural and cultural resources and visitor experience.

Within the context of this plan, the mitigation measures described below would be used to avoid or minimize potential impacts from the implementation of the action alternatives. These measures would be applied to all of the action alternatives. Additional mitigation would be identified as part of implementation planning and for individual projects to further minimize impacts to park resources.

MINED NOURISHMENT MATERIAL

Nourishment material used during the implementation of the proposed restoration alternatives would be similar to the existing beach material to mimic natural processes. Selection and assessment of mine site material would be conducted prior to placement of the material. Mine site material would be similar in grain size distribution to the existing native beach material. The chemistry of sediment at the mine site would closely match that of the natural beach sediment and would be low in pollutants, silts, and clays.

NATURAL RESOURCES

General

Indiana Dunes National Lakeshore's resources, including air, water, soils, vegetation, and wildlife, would be inventoried and monitored as appropriate to provide information needed to avoid or minimize impacts of future work in the park.

- During plan implementation, NPS natural resource staff would identify areas to be avoided.
- Fencing or other means would be used to protect sensitive resources adjacent to nourishment activity areas.
- Nourishment activities would be monitored by resource specialists, as needed.
- Construction materials would be kept in work areas, especially if the work takes place near water bodies.
- Best management practices would be employed to reduce the introduction of invasive species during construction work and other soil-disturbing activities.
- Food-related items or rubbish brought into the park would be removed.

Air Quality

- Measures to manage dust during beach nourishment would be implemented and would include the following: stabilize soils with water, minimize vegetation clearing, revegetate with native species, cover haul trucks, and employ speed limits on unpaved roads.
- Equipment and vehicle emissions would be minimized by the following measures: limit idle times (by either shutting equipment off when not in use or restricting the time of idling), maintain equipment in proper working condition according to manufacturer's specifications, use the proper size of equipment for the work being performed, and train equipment operators in proper use of equipment.
- The use of equipment with new technologies (e.g., repowered engines, electric drive trains) and use of alternative fuels for generators (e.g., propane or solar) would be encouraged.

Soundscapes

- Sound abatement measures would be implemented. These measures could include the following: a schedule to minimize impacts in sound-sensitive areas, use of the best available sound management techniques wherever feasible, use of hydraulically or electrically powered impact tools when practicable, and placement of stationary sound sources as far from sensitive use areas as possible.
- Facilities would be located and designed to minimize objectionable noise.
- The idling of motors (e.g., power tools, equipment, vehicles, etc.) would be minimized.

Soils

The following discussion of soils does not mean the same as nourishment sediment.

- Soil erosion would be minimized by limiting the time that soil is left exposed and by applying other erosion management measures, such as erosion matting, silt fencing, and sedimentation basins in work areas. These measures would reduce erosion, surface scouring, and discharge to water bodies.
- Between nourishment activities filter fabric, temporary vegetative cover, and/or other means would be used as necessary to ensure stabilization of disturbed soils.
- Disturbed areas would be monitored for invasive and nonnative plants.
- After work is completed, construction areas would be revegetated with native plants in a timely period.
- To minimize soil erosion on new trails, best management practices for trail work would be used. Examples include installing water bars, checking dams and retaining walls, contouring lands to avoid erosion, and minimizing soil disturbance.

Water Resources (including Wetlands)

- To prevent water pollution during construction, equipment would be regularly inspected for leaks of petroleum and other chemicals. The use of heavy equipment in waterways would be minimized.
- Best management practices, such as the use of silt fences, would be followed to ensure that work-related effects are minimal and to prevent long-term impacts on water quality, wetlands, and aquatic species.
- Caution would be exercised to protect water resources from activities that have the potential to cause damage, such as construction, including erosion and siltation. Measures would be taken to keep unintended discharges from escaping work areas, especially near water bodies.
- Stormwater management measures would be implemented to reduce non-point source pollution discharge from parking lots and other impervious surfaces. Such actions would include oil/sediment separators, street sweeping, infiltration beds, use of permeable surfaces, and vegetated or natural filters to trap or filter stormwater runoff.
- Activities involving dredging or the placement of fill material below the Ordinary High Water Mark of Lake Michigan would comply with requirements of sections 401 and 404 of the Clean Water Act and with other applicable state permit programs (e.g., Great Lakes Submerged Lands Act). Impacts from potential fill or dredge activities would be assessed further and specific mitigation measures would be identified as part of final design.

Terrestrial Vegetation

- Revegetation plans would be prepared for disturbed areas and would specify such features as seed/plant source, seed/plant mixes, soil preparation, fertilizers, and mulching. To maintain genetic integrity, whenever possible, native plants that grow in the project area or region would be used in restoration efforts. Monitoring would occur to ensure that revegetation was successful, plantings were maintained, and unsuccessful plant materials were replaced.

Nonnative and Invasive Vegetation

- Special attention would be devoted to preventing the spread of nonnative and invasive weeds and other nonnative plants. Standard measures would include the following: ensure equipment arrives on-site free of mud or seed-bearing material; certify seeds and straw material as weed free; identify areas of nonnative and invasive weeds before work is performed; treat nonnative and invasive weeds or nonnative and invasives weed topsoil before work is performed (e.g., topsoil segregation, storage, herbicide treatment); and revegetate with appropriate native species.
- Equipment would be pressure-washed to ensure that it was clean and weed free before entering the park.
- Vehicle parking would be limited to road shoulders, parking areas, and previously disturbed areas.
- Monitoring and follow-up treatment of nonnative vegetation in revegetated areas would occur for several years following completion of work. Follow-up treatments would include mechanical, biological, chemical, and/or additional revegetation treatments.

Wildlife

- Techniques would be employed to reduce impacts on wildlife from beach nourishment activities, such as scheduling, biological monitoring, erosion and sediment management, the use of fencing or other means to protect sensitive resources adjacent to work areas, the removal of food-related items and rubbish brought into the national lakeshore, topsoil salvage, and revegetation. These actions would include specific work monitoring by resource specialists, as well as treatment and reporting procedures.
- Measures would be taken to reduce the potential for wildlife to access human food.
- Visitor impacts on wildlife would be addressed through visitor education programs, restrictions on visitor activities, and park ranger patrols.

Threatened and Endangered Species and Species of Concern

Mitigation actions would occur during normal park operations as well as before, during, and after nourishment activities to minimize immediate and long-term impacts on rare, threatened and endangered species. These actions would vary by project and the area of the park affected, and additional mitigation would be added as appropriate depending on the specific action and location. Many of the measures listed above for vegetation and wildlife would also benefit rare, threatened and endangered species by helping to preserve habitat. Mitigation actions specific to rare, threatened and endangered species would include the following:

- Surveys would be conducted for rare, threatened and endangered species as warranted.
- Critical habitat features would be protected and preserved whenever possible.

- Work would be conducted outside critical periods (such as nesting) for the specific species when possible. Work in areas in or near suitable threatened and endangered bird habitat would occur as late as possible in the fall/winter.
- Facilities / actions would be located and designed to avoid adverse effects on rare, threatened and endangered species. If avoidance is impractical, actions would be taken to minimize and compensate for adverse effects on rare, threatened and endangered species as appropriate and in consultation with the appropriate resource agencies. Work would be conducted outside critical periods for the specific species.
- Restoration and/or monitoring plans would be developed and implemented as warranted. These plans would include approaches for implementation, performance standards, monitoring criteria, and adaptive management techniques.
- Measures to reduce adverse effects of nonnative plants and wildlife on rare, threatened and endangered species would be implemented.
- Management practices to protect piping plover (*Charadrius melodus*) nesting areas would continue to be implemented, such as closing and fencing off beach areas from visitor use, monitoring the nesting areas throughout the breeding season, and minimizing trash along the beach that attracts piping plover predators. The National Park Service would continue to work cooperatively with the U.S. Fish and Wildlife Service (FWS) and other agency partners to identify and implement appropriate mitigation measures to protect piping plover nesting areas and critical habitat within the national lakeshore.

CULTURAL RESOURCES

All projects with the potential to affect cultural resources would be carried out consistent with Section 106 of the NHPA, as amended, to ensure that the effects would be adequately addressed. Reasonable measures would be taken to avoid, minimize, or mitigate adverse effects in consultation with the Indiana state historic preservation officer (SHPO), Tribal historic preservation officers, and, as necessary, the Advisory Council on Historic Preservation, and other interested parties. In addition to adhering to the legal and policy requirements for cultural resource protection and preservation, the National Park Service would also undertake the measures listed below to further protect the park's resources.

- Areas selected for construction and beach nourishment activities would be surveyed to ensure that cultural resources (i.e., archeological sites, historic structures, and cultural landscapes) in the area of affect are identified and protected by avoidance or, if necessary, mitigation measures.
- Additional analysis would be conducted prior to construction / beach nourishment activities to verify that submerged resources would not be adversely affected. Per Section 106 of NHPA, the National Park Service would seek a determination of "no adverse effects" to historic or archeological resources from the Indiana SHPO.
- If, during beach nourishment activities, previously undiscovered archeological resources were uncovered, work in the immediate vicinity of the discovery would be halted immediately until the resources were identified and documented, and an appropriate mitigation strategy was developed in consultation with the Indiana state historic preservation officer and, if necessary, associated American Indian tribes.

- Cultural landscapes would be protected, and alterations and changes affecting cultural landscapes would follow the Secretary of the Interior's *Standards for the Treatment of Historic Properties, with Guidelines for the Treatment of Cultural Landscapes*. Actions being considered would incorporate compatible design guidelines to retain essential historic character and to mitigate potential adverse effects.

VISITOR EXPERIENCE

Measures to reduce adverse effects of beach nourishment activities on visitor safety and experience would be implemented, including project scheduling and the use of best management practices. Directional signs to orient visitors and education programs to promote understanding among visitors would continue.

Scenic Resources

Where appropriate, fencing would be used to route people away from sensitive natural and cultural resources while still permitting access to important viewpoints to the extent practicable.

HAZARDOUS MATERIALS

- Indiana Dunes National Lakeshore's spill prevention and pollution control program for hazardous materials would be followed and updated on a regular basis. Standard measures of this program include: hazardous materials storage and handling procedures; spill containment, cleanup, and reporting procedures; and limitation of refueling and other hazardous activities to upland/nonsensitive sites.
- Contract personnel would be directed to immediately stop work should suspected hazardous materials or wastes be encountered. National Park Service personnel would be notified, and appropriate remediation would be accomplished prior to resuming work.
- If appropriate, absorbent booms and other spill containment equipment and materials would be made available on-site during beach nourishment activities.

HUMAN HEALTH CONCERNS

- The source of dredged material would be determined in coordination with the Indiana DNR prior to implementation of beach nourishment activities.
- Nourishment material would be tested for *E. coli*.
- Other test parameters for nourishment material would be determined in coordination with the Indiana DNR prior to implementation of beach nourishment activities.

SHORELINE AND BEACH COMPLEX, REACHES 1 AND 2

The Indiana Dunes National Lakeshore shoreline within reach 1 is experiencing a high rate of erosion. The sandy substrate at the base of Mount Baldy has eroded away, exposing a clay layer that is now being undercut. The shoreline within reach 2 is considered dynamically stable, which means it has experienced little to no long-term changes. This stretch of shoreline contains sensitive aquatic and terrestrial habitats and is frequented by threatened and endangered species and species of concern. The natural processes of Lake Michigan have sustained the areas within reach 2; therefore, it is assumed that no direct sediment nourishment would be conducted in reach 2. The actions taken under the alternatives for reach 1 would also impact the shoreline in reach 2 (and a portion of reach 3), providing additional sediment as the nourishment material would travel downdrift via wave action and induced currents.

Proposed management actions related to terrestrial management would be conducted in conjunction with the shoreline and beach complex alternatives presented for reach 1.

ALTERNATIVE A: NO-ACTION

Under the no-action alternative, the National Park Service would continue current management practices and for the foreseeable future, there would be no new actions taken to restore the park shoreline. Alternative A establishes a baseline for evaluating changes and impacts under the other action alternatives.

Since 1974 the COE has conducted beach nourishment within reach 1 on an intermittent basis. Nourishment was made available through specific funding obtained from Congress and given to the COE to implement, but there was no program funding for routine nourishment along the shoreline. Between 1974 and 2008, approximately 1 million yd^3 of sediment, an annual average of approximately 31,500 yd^3, has been placed along the shoreline at Crescent Dune. The sediment placed has been mined from a permitted upland borrow site and transported to the lakeshore by truck. An access road has been constructed at the eastern end of Indiana Dunes National Lakeshore to facilitate placement of the upland material. There is no known designated funding source for additional nourishment activities, but the no-action alternative assumes some sort of intermittent nourishment over the next several years at about the same rate as in previous years.

The sediment (coarse material) chosen for the COE nourishment program was selected to increase retention time, but was not compatible with native materials and was not of sufficient quantity to offset the continuing erosion in reach 1. Under the no-action alternative, an estimated average quantity of 31,500 yd^3 of sediment is to be placed annually in reach 1. This quantity of sediment represents a fraction of the calculated 105,000 yd^3 of sediment budget deficit as a result of sediment trapped updrift of the Michigan City Harbor. Over the course of the 20-year timeframe of this plan, actions associated with the no-action alternative would allow for placement of approximately 630,000 yd^3 of material from upland sources. The estimated calculated sediment budget deficit for the same timeframe is approximately 2.1 million yd^3.

Despite nourishment efforts, erosion would continue along the easternmost end of the park shoreline under the no-action alternative as the quantity of material currently being placed is insufficient relative to the calculated sediment budget. Figure 2-4: Alternatives for Shoreline and Beach Complex, Reaches 1 and 2, depicts the no-action alternative. The Net Present Value (NPV) cost of the current

nourishment activities under alternative A is estimated to be approximately $9.5 million over the 20-year lifetime of this plan.

ALTERNATIVE B-1: BEACH NOURISHMENT VIA UPLAND SOURCES, ANNUAL FREQUENCY

Under alternative B-1, there would be an increase in the annual quantity of sediment placed at Crescent Dune to account for the calculated sediment budget deficit. A total of 136,500 yd^3 of nourishment material would be mined and placed on the beach each year from a permitted upland source. This quantity is the total calculated sediment budget for reach 1 (the net sediment deficit is 105,000 yd^3, obtained by subtracting the annual long-term average beach nourishment). The material would be transported to Indiana Dunes National Lakeshore via truck, using the existing access road on the eastern end of the park, and would be dispersed along the shoreline with heavy equipment. With the exception of the quantity of sediment placed, activities would be conducted in a manner similar to the current beach nourishment program conducted by the COE. The placement of the sediment on the beach in reach 1 would take approximately four months to complete every year. The placement of the nourishment material would be conducted during a time of year deemed appropriate to minimize impacts on both natural resources and visitors of the park. Figure 2-4: Alternatives for Shoreline and Beach Complex, Reaches 1 and 2, depicts alternative B-1.

The implementation of the actions associated with alternative B-1 would maintain the current shoreline position as the calculated sediment budget deficit would be fulfilled. Additional sediment placed on the beach would result in an initial increase in beach width at the base of Mount Baldy. The 136,500 yd^3 of sediment would be sufficient to prevent additional erosion of the current shoreline for one year, as natural wave action and storm events would continue to erode the sediment after placement. The shorelines downdrift of Mount Baldy would receive an infusion of sediment following the material placement at Crescent Dune, thus affecting not only reach 1, but reach 2 and a portion of reach 3 as well.

The sediment used for beach nourishment would be selected to be compatible with native site sediment, meaning similar in terms of color, shape, size, mineralogy, compaction, organic content, and texture. Any beach nourishment material would be free of harmful chemical contaminants, trash, debris, and large pieces of organic material. The total estimated NPV cost of implementing alternative B-1 would be approximately $43.8 million over the 20-year lifetime of this plan.

ALTERNATIVE B-5: BEACH NOURISHMENT VIA UPLAND SOURCES, FIVE-YEAR FREQUENCY

Under alternative B-5, the amount of sediment material deposited in reach 1 would fulfill the calculated sediment budget deficit. Rather than conducting annual nourishment activities as proposed under alternative B-1, the actions associated with alternative B-5 would place a total of 682,500 yd^3 of sediment in reach 1 every five years. As under alternative B-1, the nourishment material would be mined from a permitted upland source, transported to the park via truck, and dispersed along the shoreline with heavy equipment. With the exception of the quantity of sediment placed, activities would be conducted in a manner similar to the current beach nourishment program conducted by the COE. The placement of sediment on the beach in reach 1 would take approximately 18 months to complete every five years. Due to the sediment volume and duration of the placement activities, mitigation measures, which would include restricting access to the beach for approximately 18 months every five years, would be required to protect natural resources and to maintain the safety of park visitors and employees.

As is the case under alternative B-1, the implementation of the actions associated with alternative B-5 would maintain the current shoreline position, as the calculated sediment budget deficit would be fulfilled. Additional sediment placed on the beach would result in an initial increase in beach width at the base of Mount Baldy. The 682,500 yd^3 of sediment would be sufficient to prevent additional erosion of the current shoreline for up to five years, as natural wave action and storm events would continue to erode the sediment after placement. The shorelines downdrift of Mount Baldy subsequently would also receive an infusion of sediment following the material placement at Crescent Dune, thus affecting not only reach 1, but reach 2 and a portion of reach 3, as well.

The sediment used for beach nourishment would be compatible with native site sediment, meaning similar in terms of color, shape, size, mineralogy, compaction, organic content, and texture. Any beach nourishment material should be free of harmful chemical contaminants, trash, debris, or large pieces of organic material. The total estimated NPV cost of implementing alternative B-5 would be approximately $35.5 million over the 20-year lifetime of this plan.

ALTERNATIVE C-1: BEACH NOURISHMENT VIA DREDGED SOURCES, ANNUAL FREQUENCY

Under alternative C-1, the amount of sediment material deposited in reach 1 would fulfill the calculated sediment budget deficit. Sediment would be dredged from an updrift location. The specific location of the dredging source would be determined during the permitting process, in coordination with IDNR and based on consultation with local stakeholders and engineering constraints. A total of 136,500 yd^3 of sediment would be placed annually on the beach in reach 1 to account for the calculated sediment budget deficit. The placement of sediment on the beach in reach 1 would take approximately two months to complete every year.

As previously mentioned in the discussion of alternative B-1, the implementation of alternative C-1 would maintain the current shoreline position as the calculated sediment budget deficit would be fulfilled. Additional sediment placed on the beach would result in an initial increase in beach width at the placement area. The 136,500 yd^3 of sediment would be sufficient to prevent additional erosion of the current shoreline for up to one year on average, as natural wave action and storm events would continue to erode the sediment after placement. The shorelines downdrift of Mount Baldy subsequently would receive an infusion of sediment following the material placement at Crescent Dune, thus affecting not only reach 1, but reach 2 and a portion of reach 3, as well. Figure 2-4: Alternatives for Shoreline and Beach Complex, Reaches 1 and 2, depicts alternative C-1.

Sediment compatibility between the proposed borrow material and the native beach were assessed by comparing grain size distribution curves. A potential location within the lakeshore where beach nourishment is proposed is east, updrift, of the Michigan City Harbor structure, and the native site (i.e., the site that would provide sediment similar in terms of color, shape, size, mineralogy, compaction, organic content, and texture to the existing beach sediment) for proposed nourishment is located to the west, downdrift, of the Michigan City Harbor approximately 1.5 miles at Mount Baldy. Sediment samples used to characterize both borrow and nourishment locations were collected from the beach/shoreline area at or immediately adjacent to each location and are representative of that material (NPS 2011b). The sediment located in the borrow site for reach 1 was similar in color to the material at the native site, and no substantial levels of contaminants were present in the borrow materials (Simon and Morris 2011). The specific source location of the nourishment material would be determined in coordination with IDNR prior to implementation of a proposed alternative.

It is anticipated that the nourishment material would be placed by hydraulically pumping a sediment/water slurry onto the beach. Heavy equipment would then be used to distribute the sediment, creating the appropriate grade along the shoreline. Based on the short travel distance from Michigan City to the eastern end of reach 1, as well as the cost of removing and placing the sediment, it is estimated that alternative C-1 would be less expensive to implement and maintain than alternatives B-1 and B-5. The total estimated NPV cost of implementing alternative C-1 would be approximately $22.9 million over the 20-year lifetime of this plan.

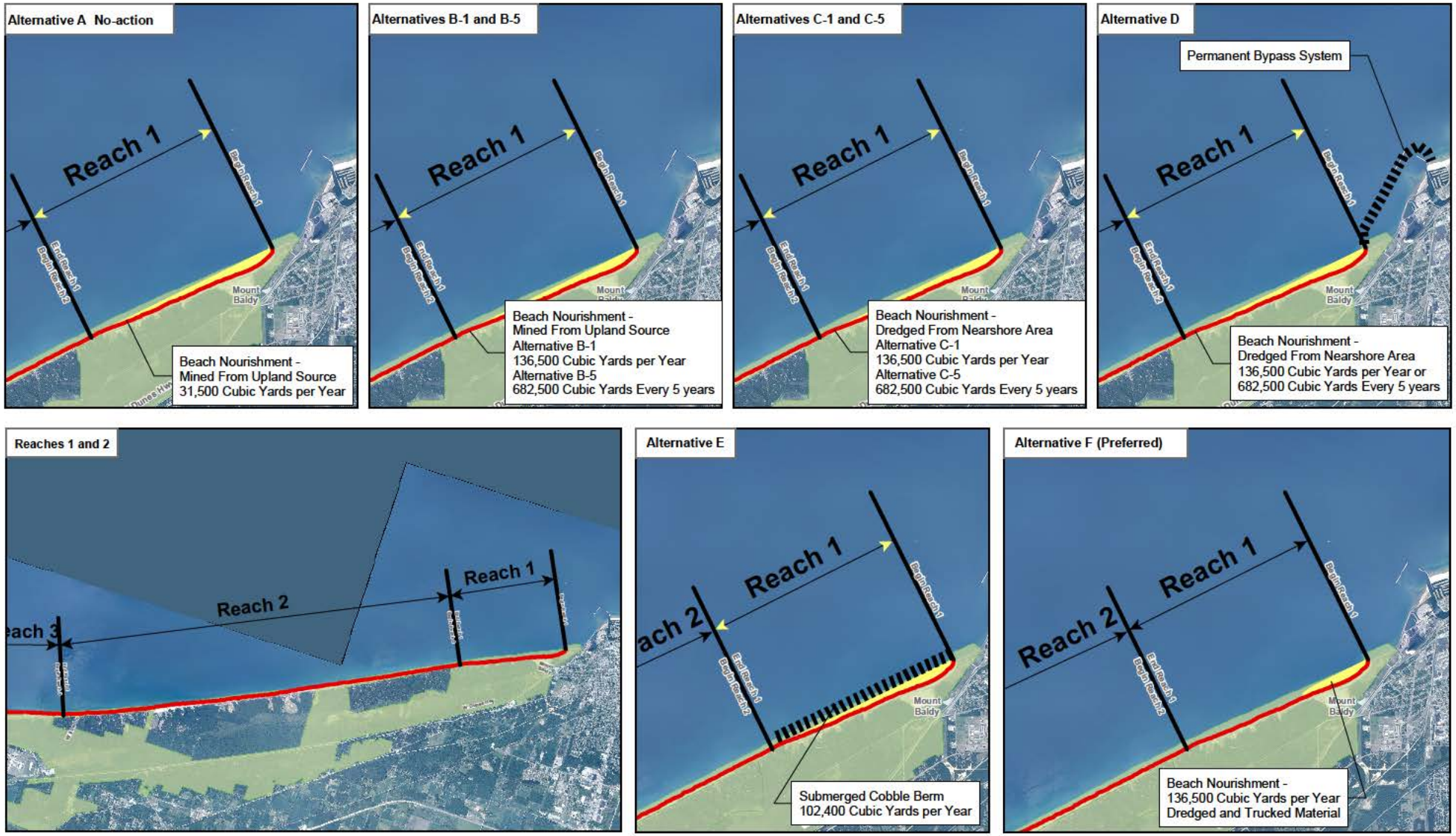
ALTERNATIVE C-5: BEACH NOURISHMENT VIA DREDGED SOURCES, FIVE-YEAR FREQUENCY

The actions proposed under alternative C-5 include a beach nourishment program using sediment dredged from an updrift location. The specific location of the dredging source would be determined during the permitting process, based on coordination with IDNR and in consultation with local stakeholders and engineering constraints. A total of 682,500 yd^3 of sediment would be placed every five years on the beach in reach 1 under this alternative to account for the calculated sediment budget deficit. The placement of sediment on the beach in reach 1 would take approximately 10 months to complete every five years.

The implementation of alternative C-5 would maintain the current shoreline profile as the calculated sediment budget deficit would be fulfilled. Additional sediment placed on the beach would result in an initial increase in beach width at the placement area. The 682,500 yd^3 of sediment would be sufficient to prevent additional erosion of the current shoreline for up to five years on average, as natural wave action and storm events would continue to erode the sediment after placement. The shorelines downdrift of Mount Baldy subsequently would receive an infusion of sediment following the material placement at Crescent Dune, thus affecting not only reach 1, but reach 2 and a portion of reach 3, as well. Figure 2-4: Alternatives for Shoreline and Beach Complex, Reaches 1 and 2, depicts alternative C-5.

Sediment compatibility between the proposed borrow material and the native beach were assessed by comparing grain size distribution curves. A potential location within the lakeshore where beach nourishment is proposed is east, updrift, of the Michigan City Harbor structure, and the native site for proposed nourishment is located to the west, downdrift of the Michigan City Harbor approximately 1.5 miles at Mount Baldy. Sediment samples used to characterize both borrow and nourishment locations were collected from the beach/shoreline area at or immediately adjacent to each location and are representative of that material (NPS 2011b). The sediment located in the borrow site for reach 1 was similar in color to the material at the native site and no substantial levels of contaminants were present in the borrow materials (Simon and Morris 2011). The specific source location of the nourishment material would be determined in coordination with IDNR prior to implementation of a proposed alternative.

It is anticipated that the nourishment material would be placed by hydraulically pumping a sediment/water slurry onto the beach. Heavy equipment would then be used to distribute the sediment, creating the appropriate grade along the shoreline. Based on the short travel distance from Michigan City to the eastern end of reach 1, the cost of removing and placing the sediment, and the reduced frequency of nourishment as compared to alternative C-1, it is estimated that the actions associated with alternative C-5 would be less expensive to implement and maintain than the previously described alternatives. The total estimated NPV cost of implementing alternative C-5 would be approximately $18.6 million over the 20-year lifetime of this plan.



Legend

- Shoreline - 2010
- Beach Nourishment Area
- Indiana Dunes National Lakeshore Park Boundary

N

0 2,000 4,000 8,000 Feet

Airphoto: Spring 2010 mosaic, USDA NAIP
Grid Spacing: 1000 meters
Spatial Reference UTM zone 16

FIGURE 2-4
ALTERNATIVES FOR SHORELINE AND BEACH COMPLEX, REACHES 1 AND 2

Indiana Dunes National Lakeshore
Shoreline Restoration and Management
Plan / Environmental Impact Statement

National Park Service / U.S. Department of the Interior
April 2014

ALTERNATIVE D: BEACH NOURISHMENT VIA PERMANENT BYPASS SYSTEM

Under alternative D, the amount of sediment material deposited in reach 1 would fulfill the calculated sediment budget deficit. Under alternative D, a permanent bypass system would be constructed and operated to transport sediment from updrift of the Michigan City Harbor to reach 1. On average, a total of 136,500 yd^3 of sediment would be bypassed annually to account for the calculated sediment budget deficit. A sediment trap would be created by initially dredging a quantity of sediment (to be determined) near the Michigan City Marina, at the end of the east jetty. An additional rubble-mound jetty modification could be required to develop an efficient sediment trap. This bypass system would be constructed along the lake bottom, around or under the existing harbor structures. Once the bypass system was constructed and operational, some annual maintenance would be required.

A system of pump and lift stations would hydraulically pump the 136,500 yd^3 of sediment to the downdrift shoreline and place it on the beach at Crescent Dune. Heavy equipment would disperse the sediment along the shoreline to create the desired beach grade to mimic natural conditions. The hydraulically placed sediment would be sufficient to maintain the current shoreline profile as the calculated sediment budget deficit would be fulfilled. Additional sediment placed on the beach would result in an initial increase in beach width at the placement area. The 136,500 yd^3 of sediment would be sufficient to prevent additional erosion of the current shoreline for up to one year on average, as natural wave action and storm events would continue to erode the sediment after placement. The shorelines downdrift of Mount Baldy subsequently would receive an infusion of sediment following the placement of nourishment material at Crescent Dune, thus affecting not only reach 1, but reach 2 and a portion of reach 3, as well.

As sediment is transported from the Michigan City Harbor vicinity to reach 1, the storage capacity of the east beach fillet would increase. Sedimentation in the federal navigation channel between the east pier of the Michigan City Harbor and the offshore breakwater would decrease slightly, resulting in a reduction in dredging requirements. The National Park Service would coordinate with stakeholders in order to implement this alternative. Additional analysis and compliance would be necessary prior to implementation of the actions associated with alternative D. The cost of implementing the actions associated with alternative D include the initial construction of the permanent bypass system, as well as maintenance and operation of the system over the 20-year lifetime of this plan. Implementing alternative D has a NPV cost of approximately $35.4 million. Figure 2-4: Alternatives for Shoreline and Beach Complex, Reaches 1 and 2, depicts alternative D.

ALTERNATIVE E: SUBMERGED COBBLE BERM AND BEACH NOURISHMENT, ANNUAL FREQUENCY

Under alternative E, the amount of sediment material deposited in reach 1 would fulfill the calculated sediment budget deficit. Under this alternative, a submerged cobble berm would be constructed parallel to the shoreline in approximately 10 feet of water depth at low water datum, between the western terminus of the Northern Indiana Public Service Company (NIPSCO) seawall and the eastern terminus of reach 2. The submerged cobble berm would be used in conjunction with a beach nourishment program to restore reach 1 of Indiana Dunes National Lakeshore. The objectives of constructing the submerged cobble berm would be to stabilize the shoreline downdrift of the Michigan City Harbor by reducing the quantity of sediment needed for beach nourishment, to enhance aquatic habitat by diversifying the nearshore substrate, and to improve shoreline protection during storm events.

A quantity of up to 102,400 yd^3 of sediment obtained from a dredged source would be hydraulically placed on the beach in reach 1 annually to provide nourishment and protection of the shoreline. The source location of the nourishment material would be determined in coordination with IDNR in areas of accretion so that dredging activities would not disturb areas of equilibrium. The submerged cobble berm would be comprised of appropriate-sized aggregate material from local glacial deposits which would dissipate over time via natural coastal processes such as wave action and storm events. This dispersion process would take up to five years, after which the aggregate material would cover the clay lakebed, protecting it against further down-cutting (process of deepening of the nearshore area due to wave scour). The length of time necessary for breakdown of the submerged cobble berm would depend largely on the final design, including the size of the aggregate material used, and also future lake processes (e.g., frequency and intensity of storm events). Until the aggregate material dissipates, the submerged cobble berm would temporarily present a possible safety concern to vessels traveling near the shoreline. Signs would be installed to warn the public of potential hazards. Over time, the submerged cobble berm would have a natural appearance and would not adversely alter the viewshed from elevated heights. Based on the offshore location, which would be along the existing 10-foot water depth contour, the submerged cobble berm would not present safety concerns for beach users.

The potential effectiveness of a submerged cobble berm has been analyzed in previous physical and numerical modeling studies (Baird 2000). Various dimensions and sizes of aggregate material were tested. Based on the results of the investigations, a 2- to 9-inch diameter aggregate submerged cobble berm placed at 10 feet below low water datum with a crest approximately 4 feet below low water datum was identified as a feasible conceptual design to be considered. Some cobbles would get pushed landward toward the beach; however, most of the berm material would remain offshore of the 5-foot to 6.5-foot contour from the beach, and the area from the shore to this contour would remain generally free of cobbles.

The submerged cobble berm proposed under alternative E would reduce shoreline erosion by breaking wave energy in the nearshore, thus allowing for greater sediment retention along the beach (Baird 2000). As previously described, the submerged cobble berm would break down over time and become part of the shoreline sediment mix. As a result, a reduced quantity of beach nourishment would be required to fulfill the calculated sediment budget deficit (25% material reduction over the projected life of the berm). The specific reduced quantity of sediment needed in conjunction with the submerged cobble berm has not been calculated; however, the amount would be determined with additional analysis prior to implementation of the actions associated with alternative E.

The total estimated cost of implementing alternative E would be approximately $24.8 million over the 20-year lifetime of this plan.

Additional analysis would be required prior to implementation of the actions associated with alternative E, particularly in the design phase. Figure 2-5: Alternative E: Submerged Cobble Berm and Beach Nourishment, Annual Frequency for Reaches 1 and 2, depicts alternative E.

ALTERNATIVE F: BEACH NOURISHMENT, ANNUAL FREQUENCY WITH A MIX OF SMALL NATURAL STONE AT THE SHORELINE (PREFERRED ALTERNATIVE)

Under alternative E, the amount of dredged sediment material deposited in reach 1 would fulfill the calculated sediment budget deficit. Potential sources for dredge materials lack the full spectrum of coarse sediment and stone sizes (Simon *et al.* 2013) necessary to achieve the desired grain size distribution in the

nourishment material. Therefore, under this alternative an additional volume of small native stones to the shoreline region would be added to the dredged materials at the shoreline. These small native stones would be consistent in size and volume with those presently found downdrift in the project's dynamically stable beach zones (Simon *et al.* 2013). The expectation would be that the mineralogy, physical shape, and consistency of these small native stones would be indistinguishable from the existing pebbles and small flat stones found along the shoreline.

Sediment would be dredged from an updrift location. The specific location of the dredging source would be determined during the permitting process, in coordination with IDNR and based on consultation with local stakeholders and engineering constraints. It is anticipated that the nourishment material would be placed by hydraulically pumping a sediment/water slurry onto the beach. Heavy equipment would then be used to distribute the sediment, creating the appropriate grade along the shoreline. The placement of dredged sediment would slowly widen the beach. Native stone would be brought to the site by truck and placed close to the water's edge and mixed with hydraulically delivered sand. Wave action, particularly high wave events, would mix and distribute the sediment and stone along the shoreline. It is expected that a portion of the placed coarse material could migrate in the nearshore area.

The combination of dredged and trucked in materials would be used to nourish the beach and restore reach 1 of Indiana Dunes National Lakeshore. The objectives of adding the native stone to the nourishment materials would be to stabilize the shoreline downdrift of the Michigan City Harbor by providing a more erosion resistant component and to enhance aquatic habitat by diversifying the nearshore substrate consistent with dynamically stable reaches.

A quantity up to 86,000 yd^3 of fine and medium sands would be hydraulically dredged and placed on the beach in reach 1 to protect the shoreline. Additional fractions of coarse upland material and small native stones (up to 51,000 yd^3 combined) would be added to the sediment nourishment. The total quantity of provided beach nourishment (136,500 yd^3) would be sufficient to fulfill the calculated sediment deficit in reach 1 and to maintain the existing shoreline position for one year. Using an adaptive management strategy, reach 1 would be monitored annually to determine if the desired mix of sediment and stone has been achieved (Morris *et al.* 2014; Morris and Eshlemen 2011). Because natural stone would not move downdrift as fast as sand, the addition of small native stones would cease once the desired natural condition is achieved. If monitoring shows that a substantial percentage of the stone has moved out of the system, more stone could be added as conditions warrant in later years. The combination of stone, coarse upland material, and dredged sediment would reduce shoreline erosion by providing a mix that is consistent with dynamically stable shoreline materials more resistant to wave energy.

The total estimated cost of implementing alternative F would be approximately $26.0 million over the 20-year lifetime of this plan.

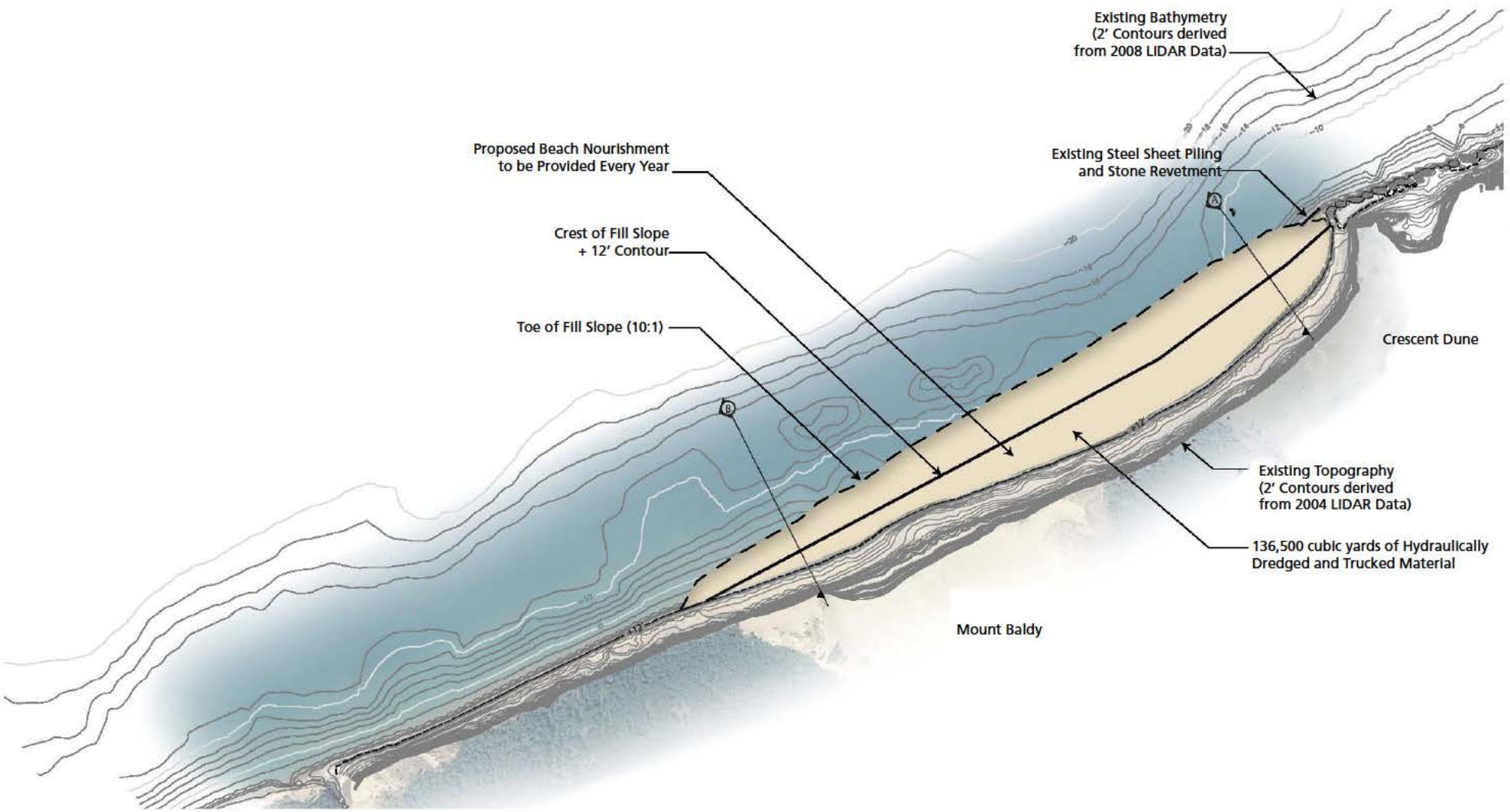


FIGURE 2-5
ALTERNATIVE F: BEACH NOURISHMENT, ANNUAL FREQUENCY WITH A MIX OF SMALL NATURAL STONE AT SHORELINE (PREFERRED ALTERNATIVE) FOR REACHES 1 AND 2

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N

1,000 0 1,000 Feet

Note: All elvations reference Verical Datum IGLD85 (0=557.5')

SHORELINE AND BEACH COMPLEX, REACHES 3 AND 4

Reach 3 of the park shoreline encompasses areas of both accretion and accelerated erosion. This disproportionate distribution of sediment is the result of interruptions to the littoral drift. In addition to the industrial and navigational harbors along Lake Michigan's southern shoreline, several sections of beach have been reinforced with hardened structures.

The park shoreline within reach 4 is considered dynamically stable. Therefore, it is assumed that no beach nourishment would be needed to allow natural lake processes to continue unassisted. The actions proposed under the action alternatives for reach 3 would impact the shoreline in reach 4, and provide additional sediment as the nourishment material would travel downdrift via natural lake processes.

ALTERNATIVE A: NO-ACTION

Under the no-action alternative, the National Park Service would continue current management practices. There would be no additional actions taken to restore the park shoreline.

The shoreline along the western portion of reach 3 is armored by approximately 2,100 linear feet of vertical steel sheet piling, an additional 1,500 linear feet of vertical steel sheet piling with toe stone, and 580 feet of stone revetment, which protects an industrial complex (see Figure 2-6: Alternatives for Shoreline and Beach Complex, Reaches 3 and 4). Approximately 120 linear feet of shoreline within this reach is unarmored and representative of the natural open shoreline appearance.

Severe storm events, including those documented in 1998 and 2010, have resulted in substantial shoreline erosion and structural damages to the protection structures in front of the Town of Ogden Dunes. Even during times of low lake levels, this portion of the shoreline is comprised of a very narrow beach. Severe erosion would be expected to continue in this area, ultimately affecting the dune habitat immediately south of the beach.

Due to a high rate of accretion on the updrift side of the Burns International Harbor (NIPSCO/Bailly intake area), maintenance dredging needs to be performed. The Burns International Harbor has been subject to maintenance dredging to maintain a safe navigation depth in the federal channels. A summary of the dredging performed in these three areas is presented below.

The area around the NIPSCO/Bailly intake has been dredged to a depth of 21 feet at low water datum by NIPSCO (1980 to 1999), and by the COE (2006 to 2009). Between 1999 and 2006, no dredging occurred around this intake. For several reasons, the maintenance program has been irregular, making planning predictions of future dredging a challenge. From 2006 through 2009, an average annual quantity of 118,000 yd^3 was removed from the intake area and placed in the nearshore in front of Ogden Dunes.

The Burns International Harbor dredging records (1985, 2000, and 2009) indicate approximately 282,000 yd^3 of dredged sediment was placed on the beach to the west of the harbor breakwater (1985, 2000) as well as in the nearshore area of Ogden Dunes (2009). Historic dredging records for the Burns International Harbor between 1986 and 2009 indicate that a total of 537,000 yd^3 of sediment was dredged and disposed in open-water, offshore of the harbor.

On a long-term annual average basis between 1986 and 2009, approximately 74,000 yd^3 were placed at Ogden Dunes in the nearshore area. It is assumed that this volume represents the baseline condition and future quantity to be placed annually. The nearshore nourishment in front of Ogden Dunes began in 1986 and

consisted of material placed approximately 1,500 feet offshore, and 1,500 feet west of the Burns International Harbor's inner breakwater. The sediment is currently permitted to be placed in 12 to 18 feet of water (at low water datum), a depth considered as safe draft for opening split-hull barges bottom hull, but yet shallow enough to prevent the placed sediment from migrating offshore (COE 2010).

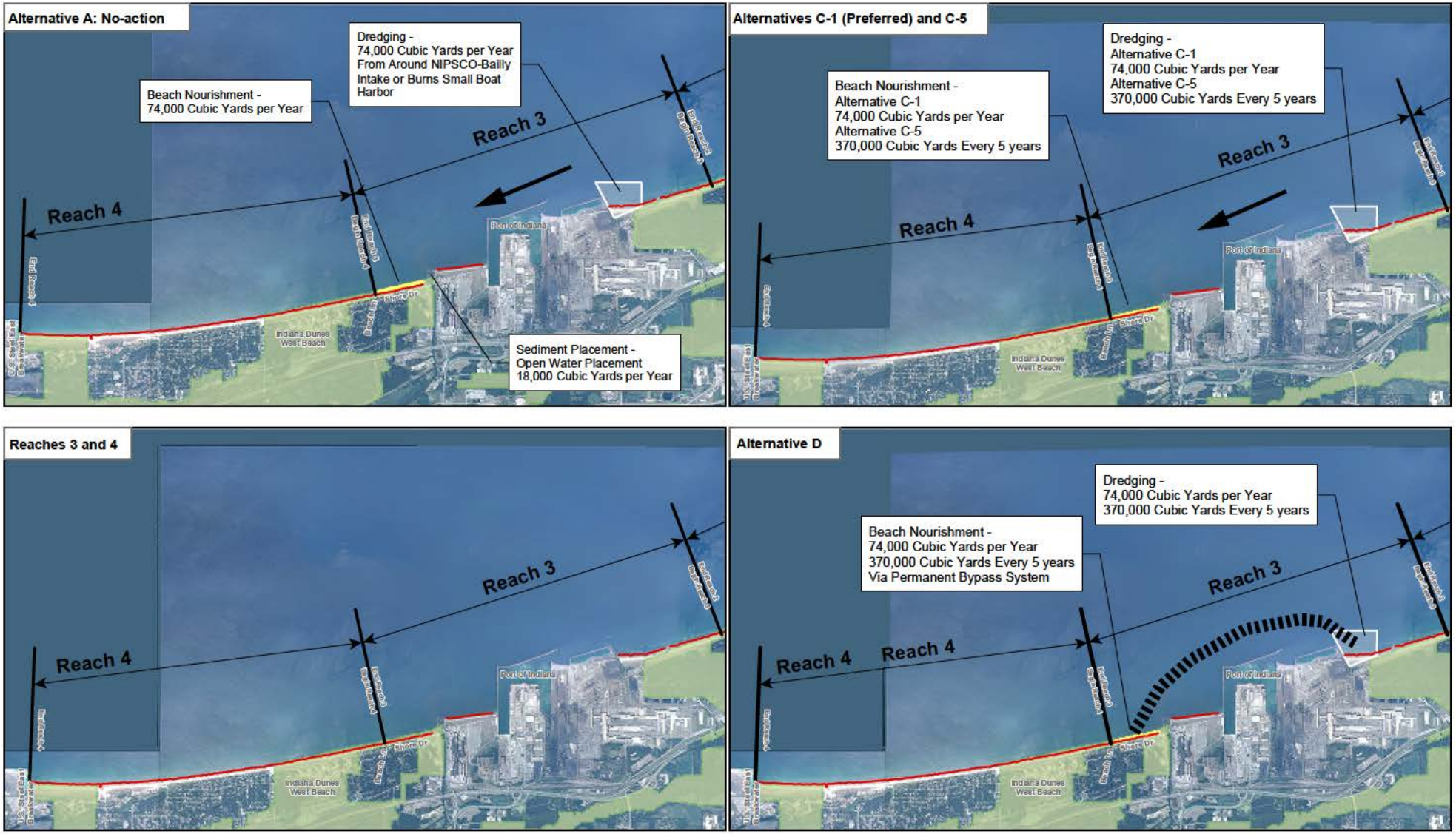
The no-action alternative assumes the continuation of the maintenance dredging of 74,000 yd^3 of sediment per year around the intake. The dredged material would be placed in the nearshore at Portage Lakefront and Riverwalk, while sediment from the Burns International Harbor would have an offshore, open-water placement.

Based on the compiled historic dredging data and the shoreline evolution analysis, and despite the ongoing maintenance dredging operations, the NIPSCO/Bailly accretion area would continue to grow, and the shoreline at Portage Lakefront and Riverwalk would continue to erode under the no-action alternative. In the future, the NIPSCO/Bailly accretion area would achieve a stable profile, allowing sediment to bypass the Arcelor-Mittal breakwater. Sediment would be captured by the federal channel at the Burns International Harbor. The accreting sediment at the west end of the beach would affect the industrial warm-water discharge location, extending it to the east toward the park shoreline. As the area of sediment accretion grows, so too would the maintenance dredging requirements for the federal channel. Excessive sedimentation around the intake would inhibit the use of the cold-water intake structure, resulting in emergency plant shutdowns. Figure 2-6: Alternatives for Shoreline and Beach Complex, Reaches 3 and 4, depicts alternative A. The cost of continuing with the existing actions associated with alternative A would be approximately $13.3 million over the 20-year lifetime of this plan.

ALTERNATIVE C-1: BEACH NOURISHMENT VIA DREDGED SOURCES, ANNUAL FREQUENCY (PREFERRED ALTERNATIVE)

Under alternative C-1 (preferred alternative), the amount of sediment material deposited in reach 3 would fulfill the estimated sediment budget deficit. Under this alternative, sediment would be dredged from an updrift location in Lake Michigan. A total of 74,000 yd^3 of sediment would be placed annually on the beach at Portage Lakefront and Riverwalk to account for the estimated sediment budget deficit. The placement of sediment on the beach in reach 3 would take approximately two months to complete every year. A potential sediment source of dredged material was identified as the area around the NIPSCO/Bailly intake. The specific location of the dredging source would be determined during the permitting process, based on coordination with the IDNR and consultation with local stakeholders and engineering constraints.

Despite ongoing maintenance dredging operations, the accreting beach updrift of the NIPSCO/Bailly complex would continue to grow under alternative C-1. The beach would potentially achieve a stable profile, allowing sediment to bypass the Arcelor-Mittal breakwater. Sediment would be captured by the federal channel at the Burns International Harbor. The accreting sediment at the west end of the beach would affect the industrial warm-water discharge location, extending it to the east toward the park shoreline. As the area of sediment accretion grows, so too would the need for maintenance dredging for the federal channel.



Legend

- Shoreline - 2010
- Beach Nourishment Area
- Indiana Dunes National Lakeshore Park Boundary

Airphoto: Spring 2010 mosaic, USDA NAIP
Grid Spacing: 1000 meters
Spatial Reference UTM zone 16

N

0 0.5 1 2
Miles

FIGURE 2-6
ALTERNATIVES FOR SHORELINE AND BEACH COMPLEX, REACHES 3 AND 4
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The implementation of the actions associated with alternative C-1 would maintain the current shoreline position as the estimated sediment budget deficit would be fulfilled. Additional sediment placed on the beach would result in an initial increase in beach width at the placement area. The 74,000 yd^3 of sediment would be sufficient to prevent additional erosion of the current shoreline for up to one year on average, as natural wave action and storm events would continue to erode the sediment after placement. The shoreline downdrift of Portage Lakefront and Riverwalk subsequently would receive an infusion of sediment following the material placement, thus affecting not only reach 3, but reach 4, as well. Figure 2-6: Alternatives for Shoreline and Beach Complex, Reaches 3 and 4, depicts alternative C-1 (preferred alternative).

Sediment compatibility between the proposed borrow material and the native beach were assessed by comparing grain size distribution curves. A potential location within the lakeshore where beach nourishment is proposed is northeast of the Port of Indiana industrial complex and the native site for proposed nourishment is located to the west, downdrift, approximately 3.5 miles at Portage Lakefront and Riverwalk. Sediment samples used to characterize both borrow and nourishment locations were collected from the beach/shoreline area at or immediately adjacent to each location and are representative of that material (NPS 2011c). The sediment located in the borrow site for reach 3 was similar in color to the material at the native site and no substantial levels of contaminants were present in the borrow materials (Simon and Morris 2011).

Under alternative C-1, the dredged material would be placed directly on the beach, thereby increasing the sediment retention time at the placement location and the efficiency of shoreline protection. It is anticipated that the nourishment material would be placed by hydraulically pumping a sediment/water slurry onto the beach. Heavy equipment would then be used to distribute the sediment, creating the appropriate grade along the shoreline. Within reach 3, it is estimated that the actions associated with alternative C-1 would be more expensive to implement and maintain than alternative A. The total estimated NPV cost of implementing alternative C-1 would be approximately $25.0 million over the 20-year lifetime of this plan.

ALTERNATIVE C-5: BEACH NOURISHMENT VIA DREDGED SOURCES, FIVE-YEAR FREQUENCY

Under alternative C-5, the amount of sediment material deposited in reach 3 would fulfill the estimated sediment budget deficit. As with alternative C-1, sediment would be dredged from an updrift location in Lake Michigan, such as near the NIPSCO/Bailly intake. The specific location of the dredging source would be determined during the permitting process, based on coordination with the IDNR and consultation with local stakeholders and engineering constraints. A total of 370,000 yd^3 of sediment would be placed every five years on the beach in reach 3 to account for the estimated sediment budget deficit. The placement of sediment on the beach in reach 3 would take approximately six months to complete every five years. The footprint of the placement area would be the entire length west of the Burns International Harbor, with an increase in beach elevation to approximately 12 feet above low water datum.

Despite ongoing maintenance dredging operations, the accreting beach updrift of the NIPSCO/Bailly complex would continue to grow under alternative C-5. The beach would potentially achieve a stable profile, allowing sediment to bypass the Arcelor-Mittal breakwater. Sediment could be trapped by the federal channel at the Burns International Harbor, which could increase maintenance dredging costs. The accreting sediment at the west end of the beach would also affect the industrial warm-water discharge location, extending it to the east further toward the park shoreline. As the area of sediment

accretion grows, so too would the need for maintenance dredging for the federal channel. Implications for the long-term shoreline placement of dredged sediment on the beach are unknown; however, additional analysis would be conducted in a later phase of the planning process.

The implementation of the actions associated with alternative C-5 would maintain the current shoreline position as the estimated sediment budget deficit would be fulfilled. Additional sediment placed on the beach would result in an initial increase in beach width at the placement area. The 370,000 yd^3 of sediment would be sufficient to prevent additional erosion of the current shoreline for up to five years on average, as natural wave action and storm events would continue to erode the sediment after placement. The shoreline downdrift of Portage Lakefront and Riverwalk subsequently would receive an infusion of sediment following the material placement, thus affecting not only reach 3, but reach 4, as well. Figure 2-7: Alternative C-5 Beach Nourishment via Dredged Sources, Five-Year Frequency for Reaches 3 and 4, depicts alternative C-5.

Sediment compatibility between the proposed borrow material and the native beach were assessed by comparing grain size distribution curves. A potential location within the lakeshore where beach nourishment is proposed is northeast of the Port of Indiana in and the native site for proposed nourishment is located to the west, downdrift, approximately 3.5 miles at Portage Lakefront and Riverwalk. Sediment samples used to characterize both borrow and nourishment locations were collected from the beach/shoreline area at or immediately adjacent to each location and are representative of that material (NPS 2011c). The sediment located in the borrow site for reach 3 was similar in color to the material at the native site and no substantial levels of contaminants were present in the borrow materials (Simon and Morris 2011).

Under alternative C-5, the dredged material would be placed directly on the beach, thereby increasing the sediment retention time at the placement location and the efficiency of shoreline protection. The nourishment material would be placed by hydraulically pumping a sediment/water slurry onto the beach. Heavy equipment would then be used to distribute the sediment, creating the appropriate grade along the shoreline. Within reach 3, it is estimated that the actions associated with alternative C-5 would be less expensive to implement and maintain than alternative C-1. The total estimated NPV cost of implementing alternative C-5 would be approximately $20.3 million over the 20-year lifetime of this plan.

ALTERNATIVE D: BEACH NOURISHMENT VIA PERMANENT BYPASS SYSTEM

Under alternative D, the amount of sediment material deposited in reach 3 would fulfill the estimated sediment budget deficit. A permanent bypass system would be constructed and operated under this alternative to transport sediment from updrift of the NIPSCO/Bailly complex to Portage Lakefront and Riverwalk. A total of 74,000 yd^3 of sediment would be bypassed annually to account for the estimated sediment budget deficit. A sediment trap would be created by initially dredging a quantity of sediment (to be determined) east of the NIPSCO intake. An additional rubble-mound jetty modification could be required to develop an efficient sediment trap. The permanent bypass system would be constructed along the lake bottom, around the existing harbor structures. After the permanent bypass system was constructed and operational, some annual maintenance would be required.

Under alternative D, a permanent bypass system of pump and lift stations would hydraulically pump the 74,000 yd^3 of sediment to the downdrift shoreline and place it on the beach in the vicinity of Portage Lakefront and

Riverwalk. Heavy equipment would disperse the sediment along the shoreline to create the appropriate beach grade. The hydraulically placed sediment would be sufficient to maintain the current shoreline position as the estimated sediment budget deficit would be fulfilled. Additional sediment placed on the beach would result in an initial increase in beach width at the placement area. The 74,000 yd^3 of sediment would be sufficient to prevent additional erosion of the current shoreline for up to one year on average, as natural wave action and storm events would continue to erode the sediment after placement. The shorelines downdrift of Portage Lakefront and Riverwalk subsequently would receive an infusion of sediment following the placement of nourishment material, thus affecting not only reach 3, but reach 4, as well.

As sediment was transported from the NIPSCO/Bailly complex to Portage Lakefront and Riverwalk via the permanent bypass system, the storage capacity of the east beach fillet would increase. Under alternative D, there would be an increase in the beach nourishment material retention time. A target of 74,000 yd^3 of material would be bypassed annually; however, the actual volume would fluctuate based on natural factors, such as sediment supply and the local wave climate. Additional analysis and compliance would be necessary prior to implementation of the actions associated with alternative D.

The costs of implementing the actions associated with alternative D would include the initial construction of the permanent bypass system as well as maintenance and operation of the system over the 20-year lifetime of this plan. Alternative D would cost approximately $23.3 million to implement. Figure 2-6: Alternatives for Shoreline and Beach Complex, Reaches 3 and 4, depicts alternative D.

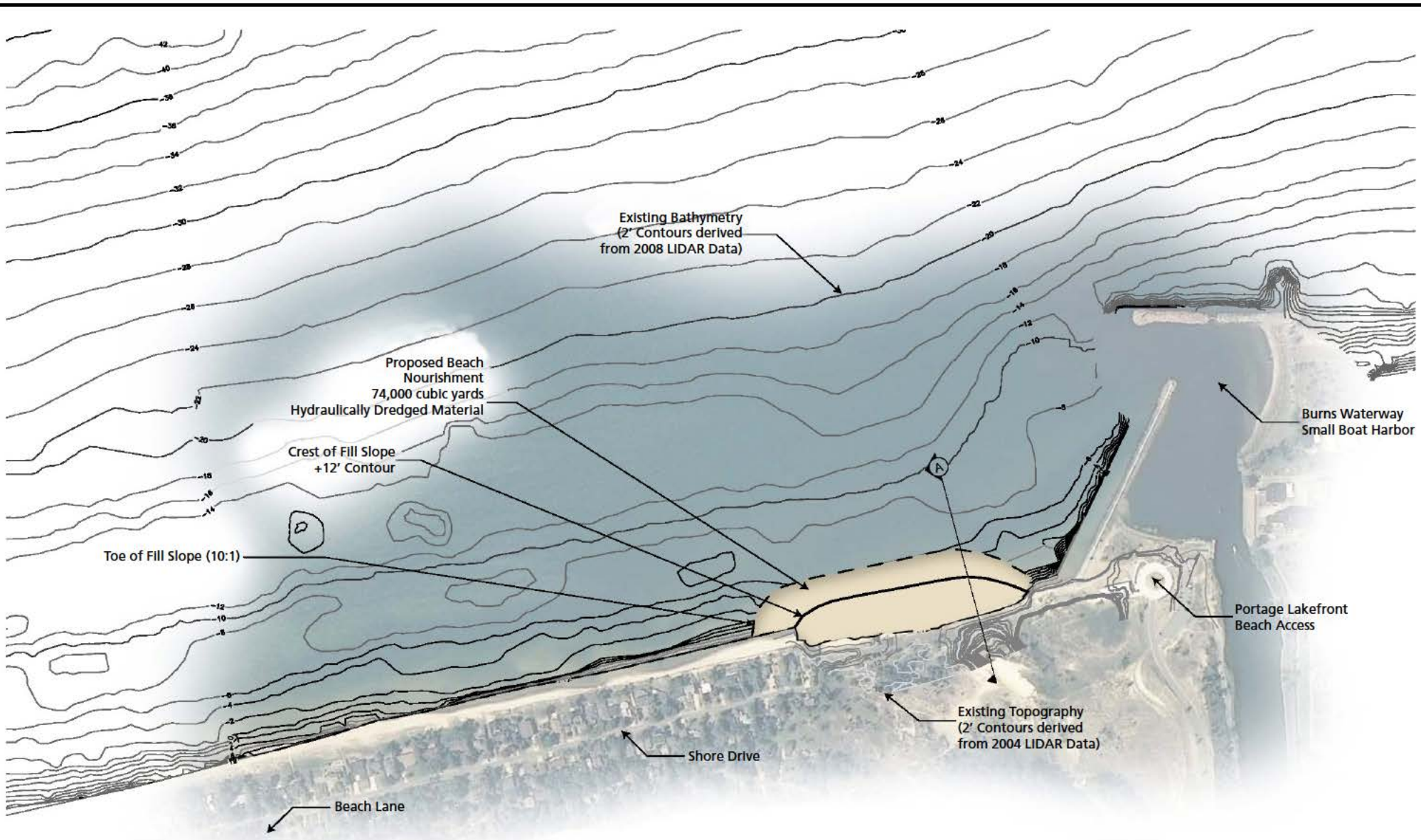

FIGURE 2-7

ALTERNATIVE C-1: BEACH NOURISHMENT VIA DREDGED SOURCES, ANNUAL FREQUENCY (PREFERRED ALTERNATIVE) FOR REACHES 3 AND 4

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N

800 0 800 Feet

Note: All elevations reference Vertical Datum IGLD85 (0=557.5')

FOREDUNE AND DUNE COMPLEX

In addition to the shoreline restoration alternatives, this plan includes natural resource management strategies for the protection and improvement of the park's terrestrial ecosystem within the project area. Plant communities and physiography are continually changing with the disturbance-prone habitats of the foredune complex. The foredune and dune complex encourages biological diversity unique to this region of the country. Migratory bird habitat, intradunal wetlands, and the various stages of dune succession are critical components of the park. The National Park Service is responsible for the protection of these sensitive habitats. Protection is currently accomplished with the following management strategies:

- preservation and restoration of sensitive habitats
- management of nonnative invasive plant species
- reduction of anthropogenic influences on native dune vegetation and critical habitat

The National Park Service is currently in the process of preparing an environmental assessment (EA) for a Great Lakes Invasive Plant Management Plan for parks located in the Great Lakes region. The National Park Service is proposing to use integrated pest management strategies to guide the development of the Great Lakes Invasive Plant Management Plan / EA. The National Park Service defines integrated pest management "as a decision-making process that coordinates knowledge of pest biology, the environment, and available technology to prevent unacceptable levels of pest damage, by cost-effective means, while posing the least possible risk to people and park resources" (NPS 2011c). Integrated pest management employs physical, chemical, mechanical, cultural, biological, and education methodologies to effectively manage and minimize the impacts of invasive plants. Once completed, the Great Lakes Invasive Plant Management Plan would establish a long-term management strategy to mitigate the current and emerging ecological effects of invasive plants within the Great Lakes region.

Nonnative invasive plant species are currently affecting sensitive habitats and species of special concern. According to the park's Invasive Plant Management Strategy (NPS 2011d), more than 130 species of special concern have the potential to be affected by nonnative invasive plant species. Species of special concern, including threatened and endangered species, as well as critical habitat, would be monitored and protected under all alternatives of this plan.

An adaptive terrestrial management approach would account for future uncertainties and maximize the outcomes of resource management activities. The lakeshore area, including the foredune and dune complex, faces numerous issues related to invasive species and coastal processes. Park resource managers would have flexibility regarding management actions and strategies to produce desired conditions within the project area under this plan.

The park is an attractive destination for visitors and local residents. Mount Baldy (located in reach 1) is the only dune in the lakeshore where climbing is allowed on designated trails. Visitors hike the dune and from the top, on a clear day, can view Chicago's skyline and the southern Lake Michigan shoreline. However, numerous social trails have developed in non-designated areas on Mount Baldy and other areas of the park. West Beach (located in reach 4) is one of the most popular and highly visited entry points in the park. Numerous social trails extend from the parking lots to the beach. Portage Lakefront and Riverwalk (located in reach 3) has also become a popular destination for visitors and local residents, and social trails that cut across the dunes to access the beach have increased substantially. As a result, ecologically sensitive areas, such as

highly erodible dune slopes, have been affected. These social trails are accelerating erosion and habitat degradation while serving as pathways for nonnative invasive plant species. As visitor use increases, so does the trampling of native vegetation.

The park currently utilizes management tools such as closing trails, developing new trails, realigning trails, fencing, signs, ticketing/fining, and visitor education to manage anthropogenic influences.

FOREDUNE AND DUNE COMPLEX, REACH 1

Mount Baldy, located at the eastern terminus of reach 1, is one of the most popular and highly visited dunes in the park. It is best characterized by stabilized dune forests with a degraded and highly eroded foredune complex. The beach width is relatively narrow in this area compared to other reaches. Mount Baldy has gone through drastic changes recently. The dune is moving landward and burying leeward trees and herbaceous vegetation. The erosion is in large part caused by off-trail anthropogenic disturbances, loss of dune vegetation, and a sediment supply deficit (Dillon 2011). Over the last several years, park officials at Indiana Dunes National Lakeshore have noted that Mount Baldy has begun moving inland at an alarming pace. Left unchecked, the dune could start to cover over its own parking lot in as few as seven years. The reason for the increased movement seems to be a combination of too little dune grass on top of Mount Baldy and too many people climbing its southern slope. The lack of dune grass, also known as Marram grass, allows the wind to more easily move the sediment. In addition, every footstep up and down the dune helps push sediment down the steeper southern slope toward the parking lot while also killing off Marram grass attempting to take root.

Crescent Dune is located directly behind the revetment wall at the eastern terminus of reach 1, and demonstrates moderate floristic quality compared to the other pannes at the West Beach and Miller units. The National Park Service has documented numerous species of special concern at this panne, including five stated-listed plant species. See Appendix D: Species Lists, for additional information on these species.

The western terminus of reach 1, defined by East Lakefront Drive and the rock revetments, has been infested with nonnative trees such as Siberian elm (*Ulmus pumila*) and black locust (*Robinia pseudoacacia*). This stretch of beach/foredune demonstrates the lowest floristic quality and poorest characteristic plant assemblages for the foredune complex in the project area.

Current Management Actions

Sensitive Habitat Restoration. Sensitive habitat restoration includes: preserving the panne by maintaining natural processes and providing nonnative invasive species management; restoring the foredune and dune complex by stabilizing select areas of eroded dunes with native vegetation; and fencing off highly eroded and environmentally sensitive areas on Mount Baldy and revegetating with American beachgrass (*Ammophila breviligulata*).

Invasive Vegetation Management. Invasive vegetation management includes: managing sand ryegrass (*Leymus arenarius*) and spotted knapweed (*Centaurea maculosa*) in the foredune complex; managing purple loosestrife (*Lythrum salicaria*), common reed (*Phragmites australis*), and hybrid cattail (*Typha* x *glauca*) in the panne; and managing some woody invasive vegetation such as Siberian elm, black locust, and tree-of-heaven (*Ailanthus altissima*).

Anthropogenic Influence. Management of anthropogenic influences includes: protecting the leeward slope of Mount Baldy by installing fencing; maintaining an appropriate designated route to and from Mount Baldy from the parking lot; reducing social trails;

and providing education and outreach to visitors.

Proposed Management Actions

Sensitive Habitat Restoration. Proposed management of sensitive habitat restoration includes the continuation of current management actions by preserving the pannes and restoring the foredune and dune complex through native plant revegetation.

Invasive Vegetation Management. Proposed invasive vegetation management includes continued current management actions in addition to: implementation of an early detection and rapid response program and protocols; implementation of an invasive plant management plan; providing education and outreach about the impacts of nonnative invasive plant species to visitors; managing sand ryegrass and spotted knapweed in the foredune complex and outlying areas; and managing nonnative invasive plant species along East Lakefront Drive.

Anthropogenic Influence. Proposed management of anthropogenic influences includes continue current management actions by protecting the south slope from pedestrian use; designating appropriate routes to and from parking lots to popular visitor sites; reducing social trails; and providing education and outreach to visitors. In addition, proposed management actions include: consideration of the realignment of trails; development and implementation of a mitigation plan for new proposed access points or trails to Crescent Dune; and enforcement of pedestrian access routes.

FOREDUNE AND DUNE COMPLEX, REACH 2

Reach 2 supports a dynamically stable foredune complex. The majority of blowouts in the project area are located in this reach. The best example of a Pitcher's thistle (*Cirsium pitcheri*) metapopulation is located in reach 2 of the project area. Many of the foredunes in reach 2 eventually intergrade into mature, stabilized dune forests. In addition, natural coastal processes, foredune development, and dune succession are readily observed in reach 2. Piping plovers often use shoreline habitat that is most influenced by natural processes, such as sediment deposition, natural rates of shoreline erosion, and scouring for maintenance (FWS 2003a). The U.S. Fish and Wildlife Service has determined that reach 2 is the only segment along the Indiana shoreline that currently has the physical conditions suitable for piping plover breeding activities.

The encroachment of nonnative species, particularly invasive plants, is a substantial problem that affects habitats within reach 2. A large population of Lombardy poplar (*Populus nigra*) and other invasive trees has invaded the Porter Beach unit and has the potential to invade the foredune and dune complex, including Keiser Blowout. Spotted knapweed, oriental bittersweet (*Celastrus orbiculatus*), cypress spurge (*Euphorbia cyparissias*), and garlic mustard (*Alliaria petiolata*) have also been documented in this reach.

Current Management Actions

Sensitive Habitat Restoration. Sensitive habitat restoration includes preserving the existing ecological conditions by sustaining natural coastal processes.

Invasive Vegetation Management. Invasive vegetation management includes managing existing nonnative invasive plant species. Targets include the following: sand ryegrass on the foredune; Lombardy popular along the roads; and invasive shrubs and trees, such as autumn olive (*Elaeagnus umbellata*) and black locust, at parking lots. Current management also includes the mapping and monitoring of treated nonnative invasive plant species.

Anthropogenic Influence. Management of anthropogenic influences includes providing education and outreach to visitors.

Proposed Management Actions

Sensitive Habitat Restoration. Proposed management of sensitive habitat restoration includes continued current management actions in addition to preserving the foredune and dune complex (including blowouts), and restoring Pitcher's thistle habitat and piping plover habitat.

Invasive Vegetation Management. Proposed invasive vegetation management includes continued current management actions in addition to implementation of an early detection and rapid response program and protocols; and implementation of integrated pest management strategies.

Anthropogenic Influence. Proposed management of anthropogenic influences includes the continuation of current management actions in addition to designating an appropriate route to the beach from the Kemil Road parking lot, and reducing social trails on the foredune complex, including blowouts, at the Kemil Road access point.

FOREDUNE AND DUNE COMPLEX, REACH 3

A drastically altered shoreline, including artificial harbors, lakefill revetments, detached breakwaters, and a hardened shoreline, separates the NIPSCO/Bailly unit from Portage Lakefront and Riverwalk. Portage Lakefront and Riverwalk has an intact panne and foredune complex with degraded beach plant communities. Pitcher's thistle populations are located in respective blowout communities in this reach. The high accretion zone at the revetment at the NIPSCO/Bailly beach fillet allows for lakeward development of the foredunes.

The mouth of the Burns International Harbor intake is located at Portage Lakefront and Riverwalk. The banks are extremely erodible, because it was constructed with steep slopes and sandy substrate. The erosion is jeopardizing species of special concern, including the state rare bearberry (*Arctostaphylos uva-ursi*). Portage Lakefront and Riverwalk has become a popular destination for visitors and local residents since its recent opening. As a result, visitor use and other anthropogenic influences have increased substantially in this reach. In addition, social trails that cut across the dunes to access the beach have increased substantially.

Invasive species are prevalent at Portage Lakefront and Riverwalk. Spotted knapweed, yellow sweet clover (*Melilotus officinalis*), and prairie sunflower (*Helianthus petiolaris*) have invaded roadside and trail edges through the unit. Purple loosestrife and common reed have also invaded the panne. Sand ryegrass has been observed throughout the foredune complex. In addition, oriental bittersweet and black locust trees are also encroaching upon areas within the dune complex in reach 3.

Current Management Actions

Sensitive Habitat Restoration. Sensitive habitat restoration includes preservation of the panne and the foredune complex by maintaining natural processes, and preservation of Pitcher's thistle populations at blowouts, including Portage Lakefront and Riverwalk.

Invasive Vegetation Management. Invasive vegetation management includes managing existing nonnative invasive plant species in the panne.

Anthropogenic Influence. Management of anthropogenic influences includes providing education and outreach to visitors.

Proposed Management Actions

Sensitive Habitat Restoration. Proposed management of sensitive habitat restoration includes continued current management actions in addition to restoring the foredune and dune complex by stabilizing select areas of eroded dunes with native vegetation, and preserving existing ecological conditions by sustaining natural coastal processes.

Invasive Vegetation Management. Proposed invasive vegetation management includes continued current management actions in addition to implementation of an early detection and rapid response program and protocols, and implementation of integrated pest management strategies.

Anthropogenic Influence. Proposed management of anthropogenic influences includes the continuation of current management actions in addition to reducing social trails and other anthropogenic influences on the foredune complex.

FOREDUNE AND DUNE COMPLEX, REACH 4

The foredune complex is generally more extensive in reach 4, compared to the stabilized, closed-canopy structure of the dune forests in reaches 1 and 2. Reach 4 subsequently supports a dynamically stable foredune complex. The foredune complex at the Miller unit is interrupted by leeward pannes and aquatic plant communities. The largest concentration of high quality pannes in the project area is located within West Beach. Beach pea restoration and reintroduction has also occurred in the foredune complex at the Miller unit.

West Beach is one of the most popular and highly visited entry points in the park. Numerous social trails extend from the parking lots to the beach. These trails traverse through sensitive habitat within the foredune complex.

Common reed, purple loosestrife, and white cattail (*Typha glauca*) are among the greatest concerns to the pannes in reach 4. The foredune complex is being invaded by sand ryegrass, spotted knapweed, and nonnative bush honeysuckle (*Lonicera* sp.). Yellow sweet clover and prairie sunflower nonnative invasive plant species are also invading the roadside and parking lot edges at West Beach.

Current Management Actions

Sensitive Habitat Restoration. Sensitive habitat restoration includes the preservation of the pannes at the West Beach and Miller units by managing nonnative invasive plant species, targeting purple loosestrife, common reed, and hybrid cattail.

Invasive Vegetation Management. Invasive vegetation management includes managing existing nonnative invasive plant species. Targets include: common reed, purple loosestrife, and white cattail in the pannes; sand ryegrass on the beach and foredunes; and yellow sweet clover and prairie sunflower. Current management also includes the mapping and monitoring of treated nonnative invasive plant species.

Anthropogenic Influence. Management of anthropogenic influences includes providing education and outreach to visitors.

Proposed Management Actions

Sensitive Habitat Restoration. Proposed management of sensitive habitat restoration includes continued current management actions in addition to restoring the foredune and dune complex by stabilizing select areas of eroded dunes with native vegetation, and fencing off highly eroded and environmental sensitive areas in the foredune complex to allow for ecological recovery of natural communities.

Invasive Vegetation Management. Proposed invasive vegetation management includes continued current management actions in addition to implementation of an early detection and rapid response program and protocols, and implementation of integrated pest management strategies.

Anthropogenic Influence. Proposed management of anthropogenic influences includes the continuation of current management actions in addition to designating and enforcing an appropriate route to and from the parking lots to the beach; reducing social trails; and fencing off highly eroded and environmental sensitive areas in the foredune complex, including the pannes, to reduce trampling of native vegetation.

ACTIONS AND ALTERNATIVES ELIMINATED FROM FURTHER CONSIDERATION

During the preparation of this plan, various approaches to restore Indiana Dunes National Lakeshore were discussed. Some actions and alternatives were proposed and eliminated from further consideration. The rationale for the dismissal of alternatives is provided below.

REACH 3, BEACH NOURISHMENT VIA UPLAND SOURCES

The planning team considered the possibility of conducting beach nourishment at Portage Lakefront and Riverwalk by trucking in material from an upland source. As is the case for reach 1, this alternative would have looked at conducting nourishment on an annual or frequency.

The proposed alternatives for conducting beach nourishment using an upland sediment source in reach 3 were dismissed because of the limited construction accessibility to the potential work area, lack of an appropriate haul road, and high costs associated with transporting materials over land. Maintenance dredging has occurred in the vicinity of the NIPSCO/Bailly intake since the 1980s. The COE intermittently operates a dredging program to manage sedimentation around the intake. If this program were interrupted, the sediment would continue to accrete in the area updrift of the industrial complex, pushing the adjacent warm-water discharge point farther east and north, potentially affecting the aquatic habitat along the shoreline. The sediment accumulation would result in operational concerns for NIPSCO as sediment enters its systems via the cold-water intake, and could cause emergency shutdowns and dredging activities. In the future, the NIPSCO/Bailly beach fillet may potentially achieve a stable profile, allowing natural sediment bypassing of the harbor structures. This could result in sediment accumulation in the navigational channel, consequently increasing the federal maintenance dredging. Compared to other nourishment activities proposed for reach 3, relatively high costs would be expected under this alternative in association with nourishment from upland sources due to the required travel distance and the need to construct an access road with associated staging areas. Due to the expected impacts of interrupting the maintenance dredging activities at the NIPSCO/Bailly complex and the high costs, nourishment from upland sources was not considered for reach 3.

REACH 3, ENGINEERED STRUCTURES

Initially, the planning team considered the possibility of constructing permanent submerged engineered structures along the shoreline in front of Portage Lakefront and Riverwalk. These structures would be designed as permanent detached breakwaters constructed parallel to the shoreline. Unlike the submerged cobble berm proposed for reach 1, this alternative considered placing several segmented structures that would not break down or dissipate, but that would remain in place. These breakwaters would facilitate a nourishment program by retaining sediment along the shoreline for longer periods of time.

This proposed alternative was dismissed from further consideration for several reasons. The beach along Portage Lakefront and Riverwalk would eventually expand, forming a scalloped shoreline profile. Such a beach appearance is an unnatural condition and therefore unsupported. Additionally, a scalloped beach profile would occur as sediment from the beach extended into the lake and connected to the segmented breakwaters. This new access to the breakwaters would pose a safety concern to visitors, potentially drawing

inexperienced swimmers to waters deeper than they would typically enter. The permanent submerged structures would also pose a safety concern to recreational boaters traveling near the shoreline. Despite the additional signs that would have been used to warn the public and boaters about the safety issue, as the crest of the structures would be approximately two to four feet above the LWD, the potential for accidents would have persisted.

In addition to the concerns associated with the beach profile and safety, the permanent structures associated with this alternative would also impact the visitor's viewshed. While the berms would have been constructed beneath the water surface, they would have been seen from elevated heights. Due to the expected impacts of implementing the permanent structures, this alternative was dismissed from further consideration in reach 3.

NATIONAL PARK SERVICE PREFERRED ALTERNATIVES

During the Choosing by Advantages process (previously described under "Choosing by Advantage Process" section) attributes, or characteristics, of each alternative were used to identify the alternatives that provide the National Park Service and the public the greatest advantage for the most reasonable cost. These advantages were the largest determining considerations in identifying the agency's preferred alternatives. Overall, the draft preferred alternatives provide the National Park Service with the greatest overall benefits at the most reasonable cost.

The National Park Service identified alternative E (Submerged Cobble Berm and Beach Nourishment, Annual Frequency) for reaches 1 and 2, and alternative C-5 (Beach Nourishment via Dredged Sources, Five-Year Frequency) for reaches 3 and 4, as the agency's draft preferred alternatives. These alternatives provide the best combination of strategies to protect the park's unique resources and visitor experience, while improving the park's operational sustainability within each reach. These alternatives also offer advantages to the neighboring communities. Actions under alternative E in reaches 1 and 2 provide for the greatest level of beach nourishment and habitat opportunities for desired native species. Actions under alternative C-5 in reaches 3 and 4 provide the best, and most cost-efficient method of foredune creation, and the greatest level of protection from major storm events.

However, public comment on the plan / draft EIS (July 2012) was extensive and ranged from support for the goals of the project to concerns about a number of aspects of the draft alternatives. The public was generally supportive of beach nourishment, but there was consistent, negative response to the proposed cobble berm in alternative E (preferred in the draft EIS) and the large volume of nourishment material associated with alternative C-5 (draft preferred alternatives).

While the potential impacts of the submerged cobble berm were addressed in the draft EIS, the public concern was such that the National Park Service chose to review the array of alternatives to determine the feasibility of both satisfying public concern and achieving the project goals through the development of a new hybrid alternative.

For Reaches 1 and 2 seven alternatives were initially developed including the no-action alternative. The only variation between the alternatives are in the consistency of the aggregate (sediment/rock), frequency of placement, and method of placement. Therefore a new hybrid alternative that incorporates desired aspects of multiple alternatives which would meet park purposes and objectives, yet addresses public concern with the draft preferred alternative E was developed.

The selection of alternative E was primarily due to the added benefits provided by the additional rock materials for both armoring the clay lakebed and providing a native range of substrate materials (sediment, gravel, rock) to promote a more natural ecologically diverse and sustainable shoreline and not necessarily the method of placement. Therefore, a new hybrid alternative which incorporates the full range of natural sediment aggregate using an approach other than the submerged cobble berm would still achieve the same objectives and provide the best combination of strategies to protect the lakeshore's unique resources and visitor experience, while satisfying public concerns.

As a result of public concern with the five-year beach nourishment volume in alternative C-5 for reaches 3 and 4 (draft preferred alternative), the National Park Service changed the preferred alternative in reaches 3 and 4 to alternative C-1. This alternative both achieves the project goals and satisfies public concerns.

ENVIRONMENTALLY PREFERABLE ALTERNATIVES

The National Park Service is required to identify the environmentally preferable alternative in its NEPA documents for public review and comment. Guidance from the Council on Environmental Quality (CEQ) "Forty Most Asked Questions,"(Q6a) defines the environmentally preferable alternative as "the alternative that causes the least damage to the biological and physical environment; it also means the alternative which best protects, preserves, and enhances historic, cultural, and natural resources" (46 *Federal Register* 18026, Q6a). It should be noted that there is no requirement that the environmentally preferable alternative and the NPS preferred alternative be the same. The National Park Service has identified alternative E (Submerged Cobble Berm and Beach Nourishment, Annual Frequency) for reaches 1 and 2, and alternative C-5 (Beach Nourishment via Dredged Sources, Five-Year Frequency) for reaches 3 and 4, as the environmentally preferable alternatives. These differ from the preferred alternatives selected in the plan / final EIS, which achieve the project goals and also satisfy public concerns.

In analyzing the impacts to natural resources, as summarized in tables 2-3 and 2-4, all action alternatives would benefit coastal processes. There would be adverse effects on aquatic fauna, terrestrial habitat, threatened and endangered species and species of concern, and the soundscape as a result of activities associated with the placement of nourishment material. The duration and intensity of these effects would vary depending on the source of the nourishment materials (i.e., upland or dredged) and the volume of nourishment material proposed under each alternative. Compared to the other alternatives, the NPS environmentally preferable alternatives would have similar adverse impacts on resources in the project area. Under alternative E in reaches 1 and 2, effects on all resources would be no greater than moderate adverse. Under alternative C-5 in reaches 3 and 4, effects would be no greater than short-term, moderate and adverse on all resources except aquatic fauna. There would be long-term, moderate to major, adverse impacts on aquatic fauna as fish would be displaced during nourishment activities, and fish life cycles would be interrupted. In addition, the larger footprint of the placement area under alternative C-5 in reaches 3 and 4 (when compared to the other action alternatives) would result in burial of benthic communities along most of reach 3. However, under all the action alternatives, the impacted resources (e.g., coastal processes, aquatic fauna, terrestrial habitat, threatened and endangered species and species of concern, and soundscape) would benefit in the long-term from the reduction of severe shoreline and beach erosion and the creation of a more natural ecosystem of shoreline vegetation and foredune and dune complexes and processes.

Among all action alternatives considered, the NPS environmentally preferable alternatives offer a high level of protection of natural resources along the shoreline. As a result, implementation of the NPS environmentally preferable alternatives would better mimic natural shoreline processes, and better protect the beach, foredunes, and dunes from erosion, and would better support the development of foredunes and dunes than under the no-action alternatives. The implementation of alternative E for reaches 1 and 2 would also provide potential habitat opportunities for desired native aquatic and terrestrial species to a greater degree than the other alternatives. The implementation of alternative C-5 in reaches 3 and 4 would provide the greatest potential for foredune creation and the greatest protection from major storm events when compared to the other alternatives. In addition, under both of the NPS environmentally preferable alternatives, the National Park Service would integrate resource protection and education with an appropriate range of visitor uses. For these reasons, alternative E for reaches 1 and 2 and alternative C-5 for reaches 3 and 4 are the

environmentally preferable alternatives. These alternatives best protect, preserve, and enhance natural resources and natural processes in the park.

CONSISTENCY OF THE ALTERNATIVES WITH THE NATIONAL ENVIRONMENTAL POLICY ACT OF 1969, AS AMENDED

The National Environmental Policy Act of 1969, as amended requires an analysis of how each alternative meets or achieves the purposes of the act, as stated in section 101(b). Each alternative analyzed in a NEPA document must be assessed as to how it meets the following purposes:

1. fulfill the responsibilities of each generation as trustee of the environment for succeeding generations
2. assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings
3. attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences
4. preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choices
5. achieve a balance between population and resource use, which would permit high standards of living and a wide sharing of life's amenities
6. enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources

The CEQ has promulgated regulations for federal agency implementation of NEPA (40 Code of Federal Regulations [CFR], parts 1500–1508). Section 1500.2 states that federal agencies shall, to the fullest extent possible, interpret and administer the policies, regulations, and public laws of the United States (U.S.) in accordance with the policies set forth in the act (sections 101(b) and 102(1)); therefore, other acts and NPS *Management Policies 2006* are referenced as applicable in the following discussion.

Criterion 1. Fulfill the Responsibilities of Each Generation as Trustee of the Environment for Succeeding Generations

All alternatives considered in this plan / final EIS, including alternative A, must comply with law and NPS policy (e.g., the *Organic Act of 1916* and NPS *Management Policies 2006*) that require the agency to manage park units by such means and in such a manner "that will leave them unimpaired for the enjoyment of future generations." Each alternative meets this criterion, although the "action alternatives" (alternatives B-1, B-5, C-1, C-5, D, E, and F in reaches 1 and 2; and alternatives C-1, C-5, and D in reaches 3 and 4) provide enhanced stewardship and trusteeship of the park's resources in comparison to alternative A. The no-action alternatives in reaches 1 and 2 and reaches 3 and 4 do not provide comprehensive management direction for shoreline restoration efforts and also do not provide for adequate nourishment to offset the continuing erosion along the park's shoreline.

Criterion 2. Assure for All Americans Safe, Healthful, Productive, and Aesthetically and Culturally Pleasing Surroundings

Under all alternatives, the National Park Service would strive to provide for safe, healthful, productive, and aesthetically and culturally pleasing surroundings. The ability of the park to achieve this purpose would be enhanced under all action alternatives when compared to alternative A for reaches 1 and 2 and alternative A reaches 3 and 4 by reducing shoreline erosion, creating conditions that more closely mimic natural coastal processes, and providing for enhanced development of foredune and dune complexes and processes.

Criterion 3. Attain the Widest Range of Beneficial Uses of the Environment Without Degradation, Risk of Health or Safety, or Other Undesirable and Unintended Consequences

All the action alternatives promote a wide range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable and unintended consequences. The action alternatives would allow an appropriate range of beach and lakeshore experiences for park visitors while providing additional resource protection than under the no-action alternatives for reaches 1 and 2 and reaches 3 and 4. All action alternatives include proposals to reduce social trails and other anthropogenic influences in the park. Compared to the no-action alternatives, the preferred alternatives (alternative F in reaches 1 and 2 and alternative C-1 in reaches 3 and 4) would better provide for the enhancement of natural shoreline processes, better protect the foredunes, dunes, and shoreline from erosion, and better support the development of foredune and dune complexes and processes. Ample visitor use opportunities would be available under all alternatives, and activities that promote natural processes and minimize environmental impacts would continue.

Criterion 4. Preserve Important Historic, Cultural, and Natural Aspects of Our National Heritage and Maintain, Wherever Possible, An Environment that Supports Diversity and Variety of Individual Choice

The preservation of important historic, cultural, and natural aspects of our national heritage would be maintained under the implementation of all alternatives. As discussed in the "Impact Topics Dismissed from Further Consideration" section in the "Purpose and Need for Action" chapter, the implementation of this plan would not affect historic, submerged, or archeological resources. In addition, mitigation measures (as described previously in "The Alternatives" chapter) would be implemented for the action alternatives to minimize unanticipated adverse effects to cultural resources. Under all of the action alternatives, there would be no appreciable impact on minorities or low-income populations or communities. This plan focuses on the shoreline as a whole. The alternatives were developed in consideration of the park's neighboring communities and the effects on not only park property, but also on neighboring community properties.

Criterion 5. Achieve a Balance Between Population and Resource Use that will Permit High Standards of Living and a Wide Sharing of Life's Amenities

All action alternatives would provide enhanced opportunities for visitors to access and experience the Indiana Dunes National Lakeshore's unique and diverse landscape. The NPS preferred alternatives achieve a balance between satisfying public concern and providing a high level of protection of natural resources while also providing a wide range of neutral and beneficial uses of the environment. Compared to the no-action alternatives, the preferred alternatives better provide for enhanced natural shoreline processes, protection of the foredunes and dunes, from erosion, and development of foredune and dune complexes and processes.

Criterion 6. Enhance the Quality of Renewable Resources and Approach the Maximum Attainable Recycling of Depletable Resources

In accordance with NPS *Management Policies 2006*, all the action alternatives incorporate measures to ensure that actions are conducted in an environmentally responsible and sustainable manner. The park staff would continue to demonstrate environmental leadership in implementing these shoreline restoration activities and execution of park operations would maximize the attainable recycling of depletable resources.

HOW ALTERNATIVES MEET OBJECTIVES

All action alternatives selected for analysis must meet all objectives to a large degree. The action alternatives must also address the stated purpose of taking action and resolve the need for action; therefore, the alternatives were individually assessed in light of how well they would meet the objectives of this plan / final EIS, which are stated in the "Purpose and Need for Action" chapter. This process is the foundation for determining the NPS preferred alternative. Alternatives that did not meet the objectives were not analyzed further (see the "Actions and Alternatives Eliminated from Further Consideration" section of "The Alternatives" chapter). Tables 2-2A and 2-2B: Comparison of Alternatives, compares how each of the alternatives described in "The Alternatives" chapter would meet the objectives of this plan. Table 2-3: Alternatives Impacts Table, Reaches 1 and 2, and Table 2-4: Alternatives Impacts Table, Reaches 3 and 4 summarizes the impacts under each alternative on each resource, as described in the "Environmental Consequences" chapter.

TABLE 2-2A. COMPARISON OF ALTERNATIVES, REACHES 1 AND 2

Alternative Element	Alternatives							
	Alternative A No-action	Alternative B-1 Beach Nourishment via Upland Sources, Annual Frequency	Alternative B-5 Beach Nourishment via Upland Sources, Five-Year Frequency	Alternative C-1 Beach Nourishment via Dredged Sources, Annual Frequency	Alternative C-5 Beach Nourishment via Dredged Sources, Five-Year Frequency	Alternative D Beach Nourishment via Permanent Bypass System	Alternative E Submerged Cobble Berm and Beach Nourishment, Annual Frequency	Alternative F Beach Nourishment, Annual Frequency with a Mix of Small Natural Stone at the Shoreline (Preferred Alternative)
Shoreline and Beach Complex, Reaches 1 and 2								
Average Sediment Placed	31,500 yd^3/year	136,500 yd^3/year	682,500 yd^3/every five years	136,500 yd^3/year	682,500 yd^3/every five years	136,500 yd^3/year	102,400 yd^3/year	136,500 yd^3 /year
Where Sediment Obtained From	Mined from a permitted upland borrow site or dredged from an offshore location near Michigan City	Mined from a permitted upland borrow site	Similar to alternative B-1	Dredged from an updrift location to be determined in coordination with IDNR in areas of accretion so that dredging activities would not disturb areas of equilibrium	Similar to alternative C-1	Bypassed from updrift of the Michigan City Harbor, such as near the Michigan City Marina, at the end of the east jetty	Submerged cobble berm would be constructed between the western terminus of the NIPSCO seawall and the eastern terminus of reach 2 and used in conjunction with beach nourishment activities similar to alternative C-1	Sediment dredged from an updrift location and coarse material and small native stones mined from a permitted upland borrow site.
Method of Placement	Sediment transported via truck along existing access road / heavy equipment would distribute sediment	Sediment transported via truck along existing access road / heavy equipment would distribute sediment and create appropriate gradations	Similar to alternative B-1	Sediment-water slurry hydraulically pumped on to beach / heavy equipment would distribute sediment and create appropriate beach grade	Similar to alternative C-1	Sediment would be transported via a permanent bypass system / a sediment trap would be created by initially dredging a TBD quantity of sediment / pump and lift stations would hydraulically pump sediment on to beach / heavy equipment would distribute sediment and create appropriate gradations	The submerged cobble berm would be comprised of appropriate-sized stone material from local glacial deposits which would gradually dissipate and cover the lakebed in the nearshore area	Sediment-water slurry hydraulically pumped on to beach. Coarse material and small native stones transported via truck along existing access road. Heavy equipment would mix sediment, coarse material and small native stones and distribute nourishment material to create appropriate gradations
Sediment Placement	For onshore, placed along shoreline at Crescent Dune/or offshore, deposited nearshore off reach 1	Placed along shoreline of beach in reach 1	Similar to alternative B-1	Similar to alternative B-1	Similar to alternative B-1	Placed on the beach at Crescent Dune	Lakebed-cobble, beach nourishment at Crescent Dune	Similar to alternative B-1
NPV Over 20 Years	$9.5 million	$43.8 million	$35.5 million	$22.9 million	$18.6 million	$35.4 million	$24.8 million	$26.0 million
Foredune and Dune Complex, Reach 1								
Sensitive Habitat Restoration								
	Preserve pannes by maintaining natural processes and providing nonnative invasive species management.							
	Restore the foredune and dune complex by stabilizing select areas of eroded dunes with native plant vegetation. Fence-off highly eroded and environmental sensitive areas on Mount Baldy, and revegetate with American beach grass.							
Invasive Vegetation Management								
	Manage sand ryegrass and spotted knapweed in the foredune complex	Continue current management actions. Manage sand ryegrass and spotted knapweed in the foredune complex and outlying areas. In addition, implement an early detection and rapid response program and strategies; implement an Invasive Plant Management Plan; and provide education and outreach about the impacts of nonnative invasive plant species to visitors.						
	Manage purple loosestrife, common reed, and hybrid cattail in the panne							

TABLE 2-2A. COMPARISON OF ALTERNATIVES, REACHES 1 AND 2

Alternative Element	Alternatives							
	Alternative A No-action	Alternative B-1 Beach Nourishment via Upland Sources, Annual Frequency	Alternative B-5 Beach Nourishment via Upland Sources, Five-Year Frequency	Alternative C-1 Beach Nourishment via Dredged Sources, Annual Frequency	Alternative C-5 Beach Nourishment via Dredged Sources, Five-Year Frequency	Alternative D Beach Nourishment via Permanent Bypass System	Alternative E Submerged Cobble Berm and Beach Nourishment, Annual Frequency	Alternative F Beach Nourishment, Annual Frequency with a Mix of Small Natural Stone at the Shoreline (Preferred Alternative)
	Manage some woody invasive vegetation, such as Siberian elm, black locust, and tree-of-heaven							
Anthropogenic Influences								
	Maintain an appropriate designated route to and from Mount Baldy from the parking lot	Continue current management actions by: Protecting the south slope of Mount Baldy from pedestrian use. Designating appropriate routes to and from parking lots to popular visitor sites. Reducing social trails. Providing education and outreach to visitors. Consider the realignment of trails; develop a mitigation plan for any new proposed access points or trails to Crescent Dune; and enforce pedestrian access routes.						
	Designate an appropriate route to and from Mount Baldy from the parking lot							
	Reduce social trails							
	Provide education and outreach							
Foredune and Dune Complex, Reach 2								
Sensitive Habitat Restoration								
	Preserve existing ecological conditions by sustaining natural coastal processes	Continue current management actions. In addition, preserve the foredune and dune complex, including blowouts; and restore Pitcher's thistle habitat and piping plover habitat.						
Invasive Vegetation Management								
	Manage existing nonnative invasive plant species. Targets include the following: sand ryegrass on foredunes; Lombardy popular along the roads; and invasive shrubs and trees, such as autumn olive and black locust, at parking lots	Continue current management actions. In addition, implement an early detection and rapid response program and protocols, and implement integrated pest management strategies.						
	Map and monitor treated nonnative invasive plant species							
Anthropogenic Influences								
	Provide education and outreach to visitors	Continue current management actions. In addition, designate appropriate route to the beach from the Kemil Road parking lot; and reduce social trails on the foredune complex, including blowouts, at the Kemil Road access point; and provide education and outreach to visitors.						

TABLE 2-2A. COMPARISON OF ALTERNATIVES, REACHES 1 AND 2

Alternative Element	Alternatives							
	Alternative A No-action	Alternative B-1 Beach Nourishment via Upland Sources, Annual Frequency	Alternative B-5 Beach Nourishment via Upland Sources, Five-Year Frequency	Alternative C-1 Beach Nourishment via Dredged Sources, Annual Frequency	Alternative C-5 Beach Nourishment via Dredged Sources, Five-Year Frequency	Alternative D Beach Nourishment via Permanent Bypass System	Alternative E Submerged Cobble Berm and Beach Nourishment, Annual Frequency	Alternative F Beach Nourishment, Annual Frequency with a Mix of Small Natural Stone at the Shoreline (Preferred Alternative)
How the Alternatives Meet the Objectives of the Plan								
Shoreline Restoration Does the alternative develop strategies that would support the reestablishment of more sustainable shoreline sediment movement and a more natural ecosystem of shoreline vegetation and foredune and dune complexes?								
	No - Under the no-action alternative the park would not develop strategies for sustainable shoreline sediment movement.	Yes - Under the proposed action alternatives, strategies for sustainable shoreline sediment movement and a more natural ecosystem of the shoreline would be developed.						
Exotic and Invasive Species Does the alternative develop new strategies to identify, manage, and remove aquatic and terrestrial exotic and invasive species; and develop strategies to support ongoing management efforts to remove aquatic and terrestrial exotic and invasive species, and to prevent conditions detrimental to those effects?								
	No - Under the no-action alternative, no new strategies would be developed.	Yes - Under the proposed action alternatives, new strategies to identify, manage, and remove aquatic and terrestrial exotic and invasive species, and new strategies to support ongoing management efforts to remove aquatic and terrestrial exotic and invasive species would be developed.						
Management Methodology Does the alternative determine shoreline desired conditions that would serve as thresholds for management actions within Indiana Dunes National Lakeshore, and develop and implement an adaptive management approach for maintaining a sustainable shoreline ecosystem within Indiana Dunes National Lakeshore?								
	No - Under the no-action alternative, there would be no adaptive management approach.	Yes - Under the proposed action alternatives, desired conditions would be developed and an adaptive management approach would be implemented.						

Notes:

NPV = net present value

TBD = to be determined

yd^3 = cubic yards

TABLE 2-2B. COMPARISON OF ALTERNATIVES, REACHES 3 AND 4

Evaluation Criteria	Alternatives			
	Alternative A No-action	Alternative C-1 Beach Nourishment via Dredged Sources, Annual Frequency (Preferred Alternative)	Alternative C-5 Beach Nourishment via Dredged Sources, Five-Year Frequency	Alternative D Beach Nourishment via Permanent Bypass System
Shoreline and Beach Complex, Reaches 3 and 4				
Long-term Average Sediment Placed	74,000 yd^3/year	74,000 yd^3/year	370,000 yd^3/every five years	74,000 yd^3/year
Where Sediment Obtained From	Dredged from around the NIPSCO/Bailly intake or the Burns International Harbor	Dredged from an updrift location in Lake Michigan, to be determined in coordination with IDNR in areas of accretion so that dredging activities would not disturb areas of equilibrium.	Similar to alternative C-1	Bypassed from updrift of the NIPSCO/Bailly complex to Portage Lakefront and Riverwalk site
Method of Placement	Open water disposal between 12 and 18 feet of water depth at Low Water Datum	Sediment-water slurry would be hydraulically pumped on to beach / heavy equipment would distribute sediment and create appropriate beach grade	Similar to alternative C-1	Sediment would be transported via a permanent bypass system / a sediment trap would be created by initially dredging a TBD quantity of sediment / pump and lift stations would hydraulically pump sediment on to beach / heavy equipment would distribute sediment and create appropriate gradations
Sediment Placement	Open water disposal between 12 and 18 feet of water depth at Low Water Datum using open split-hull barges	Placed on the beach at Portage Lakefront and Riverwalk site	Similar to alternative C-1	Similar to alternative C-1
NPV Over 20 Years	$13.3 million	$25.0 million	$20.3 million	$23.3 million
Foredune and Dune Complex, Reach 3				
Sensitive Habitat Restoration				
	Preserve panne and foredune complex by maintaining natural processes	Continue current management actions. In addition, restore the foredune and dune complex by stabilizing select areas of eroded dunes with native vegetation, and preserve existing ecological conditions by sustaining natural coastal processes.		
	Preserve Pitcher's thistle populations at blowouts, including Portage Lakefront and Riverwalk			
Invasive Vegetation Management				
	Manage nonnative invasive plant species in the panne	Continue current management actions. In addition, implement an early detection and rapid response program and protocols, and implement integrated pest management strategies.		
Anthropogenic Influences				
	Provide education and outreach to visitors	Continue current management actions. In addition, reduce social trails and other anthropogenic influences on the foredune complex.		
Foredune and Dune Complex, Reach 4				
Sensitive Habitat Restoration				
	Preserve the pannes at the West Beach and Miller units by managing nonnative invasive plant species, targeting purple loosestrife, common reed, and hybrid cattail	Continue current management actions. In addition, restore the foredune and dune complex by stabilizing select areas of eroded dunes with native vegetation, and fence-off highly eroded and environmental sensitive areas on the foredunes to allow for ecological recovery of natural communities.		
Invasive Vegetation Management				
	Manage existing nonnative invasive plant species. Targets include the following: common reed, purple loosestrife, and white cattail in the pannes; sand ryegrass on the beach and foredunes; and yellow sweet clover and prairie sunflower.	Continue current management actions. In addition, implement an early detection and rapid response program and protocols, and implement integrated pest management strategies.		
	Map and monitor treated nonnative invasive plant species			

TABLE 2-2B. COMPARISON OF ALTERNATIVES, REACHES 3 AND 4

Evaluation Criteria	Alternatives			
	Alternative A No-action	Alternative C-1 Beach Nourishment via Dredged Sources, Annual Frequency (Preferred Alternative)	Alternative C-5 Beach Nourishment via Dredged Sources, Five-Year Frequency	Alternative D Beach Nourishment via Permanent Bypass System
Anthropogenic Influences				
	Provide education and outreach to visitors	Continue current management actions. In addition, designate and enforce appropriate routes to and from parking lots; reduce social trails; and fence-off highly eroded and environmental sensitive areas in the foredune complex, including pannes, to reduce trampling of native vegetation.		
How the Alternatives Meet the Objectives of the Plan				
Shoreline Restoration Does the alternative develop strategies that would support the reestablishment of more sustainable shoreline sediment movement and a more natural ecosystem of shoreline vegetation and foredune and dune complexes?				
	No - Under the no-action alternative, the park would not develop strategies for sustainable shoreline sediment movement.	Yes - Under the proposed action alternatives, strategies for sustainable shoreline sediment movement and a more natural ecosystem of the shoreline would be developed.		
Exotic and Invasive Species Does the alternative develop new strategies to identify, manage, and remove aquatic and terrestrial exotic and invasive species; and develop strategies to support ongoing management efforts to remove aquatic and terrestrial exotic and invasive species and to prevent conditions detrimental to those effects?				
	No - Under the no-action alternative, no new strategies would be developed.	Yes - Under the proposed action alternatives, new strategies to identify, manage, and remove aquatic and terrestrial exotic and invasive species, and new strategies to support ongoing management efforts to remove aquatic and terrestrial exotic and invasive species would be developed.		
Management Methodology Does the alternative determine shoreline desired conditions that would serve as thresholds for management actions within Indiana Dunes National Lakeshore; and develop and implement an adaptive management approach for maintaining a sustainable shoreline ecosystem within Indiana Dunes National Lakeshore?				
	No - Under the no-action alternative, there would be no adaptive management approach.	Yes - Under the proposed action alternatives, desired conditions would be developed and an adaptive management approach would be implemented.		

Notes:

NIPSCO = Northern Indiana Public Service Company
NPV = net present value
TBD = to be determined
yd^3 = cubic yards

TABLE 2-3. ALTERNATIVES IMPACTS TABLE, REACHES 1 AND 2

Impact Topic	Alternative A (No-action Alternative)	Alternative B-1 (Beach Nourishment via Upland Sources, Annual Frequency)	Alternative B-5 (Beach Nourishment via Upland Sources, Five-Year Frequency)	Alternative C-1 (Beach Nourishment via Dredged Sources, Annual Frequency)	Alternative C-5 (Beach Nourishment via Dredged Sources, Five-Year Frequency)	Alternative D (Beach Nourishment via Permanent Bypass System)	Alternative E (Submerged Cobble Berm and Beach Nourishment, Annual Frequency)	Alternative F (Beach Nourishment, Annual Frequency with a Mix of Small Natural Stone at the Shoreline) – Preferred Alternative
Coastal Processes								
Sediment Transport Process	Moderate, long-term, adverse impacts due to continued sediment budget deficit and shoreline erosion.	Moderate, long-term, beneficial impacts from balancing the sediment budget deficit and improved protection of the shoreline from erosion.	Moderate, long-term, beneficial impacts from balancing the sediment budget deficit and improved protection of the shoreline from erosion.	Moderate to major, long-term, beneficial impacts as the estimated sediment budget deficit would be provided from an updrift source, that would more closely mimic natural conditions.	Moderate to major, long-term, beneficial impacts as the estimated sediment budget deficit would be provided from an updrift source, that would more closely mimic natural conditions.	Moderate to major, long-term, beneficial impacts as the estimated sediment budget deficit would be provided from an updrift source, that would more closely mimic natural processes.	Moderate, long-term, beneficial impacts from a balanced sediment budget deficit, and additional protection of the shoreline and lake bottom from erosion.	Moderate, long-term, beneficial impacts from a balanced sediment budget deficit, and additional protection of the shoreline and lake bottom from erosion.
Foredune and Dune Formation Process	Moderate, long-term, adverse impacts due to the continued sediment budget deficit that creates a deficit of material for dune formation.	Moderate, long-term, beneficial impacts as the sediment placed on the beach would allow for additional sediment supply to create foredunes.	Moderate to major, long-term, beneficial impacts as the additional quantity of material on the beach would foster foredune development.	Moderate, long-term, beneficial impacts as the sediment placed on the beach would allow for additional sediment supply to create foredunes.	Moderate to major, long-term, beneficial impacts as the additional quantity of material on the beach would foster foredune development.	Moderate, long-term, beneficial impacts as the sediment placed on the beach would allow for additional sediment supply to create foredunes.	Moderate, long-term, beneficial impacts as the sediment placed on the beach would allow for additional sediment supply to create foredunes.	Moderate, long-term, beneficial impacts as the nourishment material placed on the beach would allow for additional sediment supply to create foredunes.
Aquatic Fauna	Minor, short-term, adverse impacts as fish would be temporarily displaced due to turbidity, and the benthic communities would be smothered during placement of sediment. Negligible, short-term, adverse impacts as nourishment activities would result in a disrupted environment, which would allow for the introduction/ establishment of invasive and nonnative species.	Minor, short-term adverse impacts as fish would be temporarily displaced due to turbidity. The benthic communities would be temporarily smothered during placement of sediment. Negligible, short-term, adverse impacts as nourishment activities would result in a disrupted environment, which would allow for the introduction/ establishment of invasive and nonnative species. Minor, long-term, beneficial impacts as there would be less environmental stress from erosion and no disturbance from dredging.	Moderate, long-term, adverse impacts due to the duration of placement activities. Fish would be displaced and fish life-cycles would be interrupted. The larger footprint of the placement area would result in smothering of benthic communities along the majority of reach 1. Negligible, short-term, adverse impacts as nourishment activities would result in a disrupted environment, which would allow for the introduction/ establishment of invasive and nonnative species. Minor, long-term, beneficial effects from reducing erosion in the area and enhancing the fish and benthic habitat.	Minor, short-term, adverse impacts as fish would be temporarily displaced due to turbidity. The benthic communities would be temporarily smothered during placement of sediment. Negligible, short-term, adverse impacts as nourishment activities would result in a disrupted environment, which would allow for the introduction/ establishment of invasive and nonnative species. Minor, long-term, beneficial effects from reducing erosion in the area and enhancing the fish and benthic habitat.	Moderate to major, short- and long-term, adverse impacts as fish would be displaced and fish life cycles would be interrupted. The larger footprint of the placement area would result in smothering of the benthic communities along the majority of reach 1. Negligible, short-term, adverse impacts as nourishment activities would result in a disrupted environment, which would allow for the introduction/ establishment of invasive and nonnative species. Minor, long-term, beneficial effects from reducing erosion in the area and enhancing the benthic and fish habitat.	Minor, short-term, adverse impacts as fish would be temporarily displaced due to turbidity. The benthic communities would be temporarily smothered during the placement of sediment. Negligible, short-term, adverse impacts as nourishment activities would result in a disrupted environment, which would allow for the introduction/ establishment of invasive and nonnative species. Minor, long-term, beneficial effects from reducing erosion in the area and enhancing the benthic and fish habitat.	Minor, short-term, adverse impacts as fish would be temporarily displaced during construction and nourishment activities. The benthic communities would be smothered during placement of the sediment. Minor, long-term, adverse impacts as the aggregate material – and associated interstitial spaces – in the submerged cobble berm would be an attractive habitat for invasive and nonnative species until the material had dissipated and was covered by sediment. Moderate, long-term, beneficial impacts as the aggregate material placed would create additional benthic and fish habitat and reduce the effects from erosion in the area.	Minor, short-term, adverse impacts as fish would be temporarily displaced during beach nourishment activities. The benthic communities would be smothered during placement of the sediment. Moderate, long-term, beneficial impacts as the coarse material and small native stones placed would create additional benthic and fish habitat and reduce the effects from erosion in the area.

TABLE 2-3. ALTERNATIVES IMPACTS TABLE, REACHES 1 AND 2

Impact Topic	Alternative A (No-action Alternative)	Alternative B-1 (Beach Nourishment via Upland Sources, Annual Frequency)	Alternative B-5 (Beach Nourishment via Upland Sources, Five-Year Frequency)	Alternative C-1 (Beach Nourishment via Dredged Sources, Annual Frequency)	Alternative C-5 (Beach Nourishment via Dredged Sources, Five-Year Frequency)	Alternative D (Beach Nourishment via Permanent Bypass System)	Alternative E (Submerged Cobble Berm and Beach Nourishment, Annual Frequency)	Alternative F (Beach Nourishment, Annual Frequency with a Mix of Small Natural Stone at the Shoreline) – Preferred Alternative
Terrestrial Habitat	Minor, short- and long-term, adverse impacts from the erosion and destabilization of habitat that would continue from taking no new actions in the park, including any actions to invite or deter invasive and nonnative plants. Taking no new actions in the park would not improve the ability of the beach to withstand storm events and preserve habitat.	Minor, short-term, adverse impacts from the introduction of invasive nonnative plant species into the park during sediment placement activities. Minor, short-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion. Negligible to minor, short-term, beneficial effects from the improved ability of the beach to withstand storm events and preserve terrestrial habitat for plants and animals.	Minor, long-term, adverse impacts from the introduction of invasive nonnative plant species into the park during sediment placement activities, and from the longer duration of nourishment activities and the larger footprint of sediment placed on the beach. Minor, long-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion, and from a reduction in the erosion and degradation of the foredune and colonization by invasive and nonnative plant species. Negligible to minor, long-term, beneficial effects from the improved ability of the beach to withstand storm events and preserve terrestrial habitat.	Negligible to minor, short-term, adverse impacts from re-vegetation efforts that would affect sensitive habitats. Minor, short-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion. Negligible to minor, short-term, beneficial effects from the improved ability of the beach to withstand storm events and preserve terrestrial habitat for plants, and since material dredged from the lake bottom would have no or limited viable nonnative invasive plant species seedbank.	Negligible to minor, short-term, adverse impacts from re-vegetation efforts that would affect sensitive habitats. Moderate, short-term, beneficial impacts from nourishment of the park shoreline. Moderate, long-term, adverse impacts from the longer duration of nourishment activities and the larger footprint of sediment placed on the beach. Negligible to minor, long-term, beneficial effects from the improved ability of the beach to withstand storm events and preserve terrestrial habitat for plants, and since material dredged from the lake bottom would have no or limited viable nonnative invasive plant species seedbank.	Negligible to minor, short-term, adverse impacts from re-vegetation efforts that would affect sensitive habitats. Minor, short-term, beneficial impacts from nourishment of the park shoreline, and from the decreased erosion and improved natural ecological setting for native plants and animals. Minor, short-term, adverse impacts as some beach vegetation would be smothered during placement activities. Negligible to minor, short-term, beneficial effects from the improved ability of the beach to withstand storm events and preserve terrestrial habitat.	Minor, long-term, beneficial impacts from dune stabilization and foredune development. Minor, long-term, adverse effects from interference with an already stable area in reach 2. Minor to moderate, long-term, beneficial impacts from restoration of the park shoreline, particularly in areas of accelerated erosion, and from the reduced consumption of material for nourishment activities. Negligible to minor, short-term, beneficial effects from the improved ability of the beach to withstand storm events and preserve terrestrial habitat for plants and animals.	Minor, long-term, beneficial impacts from dune stabilization and foredune development. Minor, long-term, adverse effects from interference with an already stable area in reach 2. Minor to moderate, long-term, beneficial impacts from restoration of the park shoreline, particularly in areas of accelerated erosion, and from the reduced consumption of material for beach nourishment activities. Negligible to minor, short-term, beneficial effects from the improved ability of the beach to withstand storm events and preserve terrestrial habitat for plants and animals.

TABLE 2-3. ALTERNATIVES IMPACTS TABLE, REACHES 1 AND 2

Impact Topic	Alternative A (No-action Alternative)	Alternative B-1 (Beach Nourishment via Upland Sources, Annual Frequency)	Alternative B-5 (Beach Nourishment via Upland Sources, Five-Year Frequency)	Alternative C-1 (Beach Nourishment via Dredged Sources, Annual Frequency)	Alternative C-5 (Beach Nourishment via Dredged Sources, Five-Year Frequency)	Alternative D (Beach Nourishment via Permanent Bypass System)	Alternative E (Submerged Cobble Berm and Beach Nourishment, Annual Frequency)	Alternative F (Beach Nourishment, Annual Frequency with a Mix of Small Natural Stone at the Shoreline) – Preferred Alternative
Threatened and Endangered Species and Species of Concern	Moderate, short-term, adverse impacts from continued erosion, loss of habitat for piping plover and Pitcher's thistle, and continued sediment budget deficit. May affect, and is likely to adversely affect piping plover and Pitcher's thistle because development of future habitat is not addressed and substantial erosion would continue. No effect on the Karner blue butterfly, Indiana bat, and eastern massasauga rattlesnake as beach nourishment activities would not affect their habitat.	Moderate to major, short-term, beneficial impacts on Pitcher's thistle and piping plover (threatened and endangered species), from the habitat restoration that would result from the expanded beach nourishment activities. Minor, short-term, adverse impacts as placement of nourishment material from an upland source would temporarily disturb the ability of piping plover to nest and for Pitcher's thistle to establish. May affect, but is not likely to adversely affect piping plover and Pitcher's thistle as beach nourishment activities would result in habitat restoration. No effect on the Karner blue butterfly, Indiana bat, and eastern massasauga rattlesnake as beach nourishment activities would not affect their habitat.	Moderate to major, long-term, beneficial impacts on Pitcher's thistle and piping plover from the habitat restoration that would result from the expanded beach nourishment activities. Moderate, long-term, adverse impacts on these species as placement of nourishment material from an upland source would disturb the ability of piping plover to nest and for Pitcher's thistle to establish. May affect, but is not likely to adversely affect piping plover and Pitcher's thistle as beach nourishment activities would result in habitat restoration. No effect on the Karner blue butterfly, Indiana bat, and eastern massasauga rattlesnake as beach nourishment activities would not affect their habitat.	Moderate to major, short-term, beneficial impacts from the habitat restoration that would result from the expanded beach nourishment activities. Minor, short-term, adverse impacts as placement of nourishment material would temporarily disturb the ability of piping plover to nest and for Pitcher's thistle to establish. May affect, but is not likely to adversely affect piping plover and Pitcher's thistle as beach nourishment activities would result in habitat restoration. No effect on the Karner blue butterfly, Indiana bat, and eastern massasauga rattlesnake as beach nourishment activities would not affect their habitat.	Moderate to major, long-term, beneficial impacts on Pitcher's thistle and piping plover from the habitat restoration that would result from the expanded beach nourishment activities. Minor to moderate, short-term, adverse impacts on these species as placement of nourishment material would disturb the ability of piping plover to nest and for Pitcher's thistle to establish. May affect, but is not likely to adversely affect piping plover and Pitcher's thistle as beach nourishment activities would result in habitat restoration. No effect on the Karner blue butterfly, Indiana bat, and eastern massasauga rattlesnake as beach nourishment activities would not affect their habitat.	Moderate to major, short-term, beneficial impacts from the habitat restoration that would result from the expanded beach nourishment activities. Minor, short-term, adverse impacts as placement of nourishment material would temporarily disturb the ability of piping plover to nest and for Pitcher's thistle to establish, and from the temporary visual intrusions being introduced in to the park during construction of the permanent bypass system. May affect, but is not likely to adversely affect piping plover and Pitcher's thistle as beach nourishment activities would result in habitat restoration. No effect on the Karner blue butterfly, Indiana bat, and eastern massasauga rattlesnake as beach nourishment activities would not affect their habitat.	Major, long-term, beneficial impacts on Pitcher's thistle and piping plover from the habitat restoration that would result from the placement of the submerged cobble berm. Minor, short-term, adverse impacts as placement of nourishment material would temporarily disturb the ability of piping plover to nest and for Pitcher's thistle to establish. May affect, but is not likely to adversely affect piping plover and Pitcher's thistle as beach nourishment activities would result in habitat restoration. No effect on the Karner blue butterfly, Indiana bat, and eastern massasauga rattlesnake as beach nourishment activities would not affect their habitat.	Major, long-term, beneficial impacts on Pitcher's thistle and piping plover from the habitat restoration that would result from placement of the nourishment material Minor, short-term, adverse impacts as placement of nourishment material would temporarily disturb the ability of piping plover to nest and for Pitcher's thistle to establish. May affect, but is not likely to adversely affect piping plover and Pitcher's thistle as beach nourishment activities would result in habitat restoration. No effect on the Karner blue butterfly, Indiana bat, and eastern massasauga rattlesnake as beach nourishment activities would not affect their habitat.
Wetlands and Pannes†	Not applicable (see note below).	Not applicable (see note below).	Not applicable (see note below).	Not applicable (see note below).	Not applicable (see note below).	Not applicable (see note below).	Not applicable (see note below).	Not applicable (see note below).
Soundscape	Minor, short-term adverse impacts from beach nourishment activities related to sound generated from the trucks hauling the sediment and equipment grading the nourishment material along the beach.	Negligible to minor, short-term, adverse impacts from beach nourishment activities related to sound generated from the trucks hauling the sediment and equipment grading the nourishment material along the beach.	Minor to moderate, long-term, adverse impacts from beach nourishment activities related to sound generated from trucks hauling sediment and equipment grading the nourishment material along the beach.	Negligible to minor, short-term, adverse impacts from beach nourishment activities related to sound generated from barges and equipment grading the nourishment material along the beach.	Minor to moderate, short-term, adverse impacts from beach nourishment activities related to sound generated from equipment grading the nourishment material along the beach and from dredging operations.	Negligible to minor, short-term, adverse impacts from the sound that would be generated from construction and associated operations of the permanent bypass system.	Negligible, short-term, adverse impacts from the beach nourishment activities related to sound generated from construction and beach nourishment activities and equipment grading the nourishment material along the beach.	Negligible to minor, short-term, adverse impacts from beach nourishment activities related to sound generated from the barges and the trucks hauling the stone and equipment mixing and grading the nourishment material along the beach.

TABLE 2-3. ALTERNATIVES IMPACTS TABLE, REACHES 1 AND 2

Impact Topic	Alternative A (No-action Alternative)	Alternative B-1 (Beach Nourishment via Upland Sources, Annual Frequency)	Alternative B-5 (Beach Nourishment via Upland Sources, Five-Year Frequency)	Alternative C-1 (Beach Nourishment via Dredged Sources, Annual Frequency)	Alternative C-5 (Beach Nourishment via Dredged Sources, Five-Year Frequency)	Alternative D (Beach Nourishment via Permanent Bypass System)	Alternative E (Submerged Cobble Berm and Beach Nourishment, Annual Frequency)	Alternative F (Beach Nourishment, Annual Frequency with a Mix of Small Natural Stone at the Shoreline) – Preferred Alternative
Visitor Experience	Minor to moderate, short- and long-term, adverse impacts from continued temporary beach closings and ongoing degradation of popular visitor amenities from continued shoreline erosion.	Minor, short-term, adverse impacts from temporary beach and trail closings for nourishment activities in reach 1, and the visual intrusions being introduced in to the park (i.e., grading equipment). Minor, short-term, beneficial impacts from the temporary increase in beach size, and the reduction in future trail closings.	Minor to moderate, long-term, adverse impacts from the visual intrusions being introduced into the park during beach nourishment activities (i.e., grading equipment), and from the beach and trail closings during placement work. Minor, short- and long-term, beneficial impacts from the temporary increase in beach size, and the future reduction in beach closings for nourishment activities due to the decrease in erosion.	Minor, short-term, adverse impacts from the temporary beach closings, and visual intrusions being introduced into the park during placement activities (i.e., grading equipment). Minor, short-term, beneficial impacts from the temporary increase in beach size, and the decrease in future beach closings that would result from less restoration work having to be performed (from reduced erosion.	Moderate, short-term, adverse impacts from temporary beach and trail closings during dredging and placement activities, and from the visual intrusions such activities and equipment would introduce into the visitor's viewshed. Minor, short- and long-term, beneficial impacts from the temporary increase in beach size and the decrease in future beach closings that would result from reduced erosion (and thus reduced maintenance/restoration activities that require beach closings).	Minor, short-term, adverse impacts from temporary beach closings, construction of the permanent bypass system, and hazards posed to nonconfident swimmers by the lift and pump stations. Minor, short-term, beneficial impacts from the reduction in future beach closings that would result from less cyclic maintenance and restoration work needing to be performed from reduced erosion, as well as from the temporary increase in beach size. Minor, long-term, adverse impacts from the visual intrusion the small lift stations would introduce to the park.	Minor, short- and long-term, adverse impacts from the temporary beach closings during construction of the submerged cobble berm, and from the visual intrusion the submerged cobble berm would introduce into the park and the safety concerns it would pose before dissipation. The park would consider implementing mitigation measures to offset safety concerns. Minor, short- and long-term, beneficial impacts from the reduced maintenance demands and reduced restoration demands that would result in fewer beach and trail closings.	Minor, short-term, adverse impacts from temporary beach and trail closings for nourishment activities in reach 1, and the visual intrusions being introduced in to the park (i.e., mixing and grading equipment). Minor, short-term, beneficial impacts from the temporary increase in beach size, and the reduction in future trail closings.

TABLE 2-3. ALTERNATIVES IMPACTS TABLE, REACHES 1 AND 2

Impact Topic	Alternative A (No-action Alternative)	Alternative B-1 (Beach Nourishment via Upland Sources, Annual Frequency)	Alternative B-5 (Beach Nourishment via Upland Sources, Five-Year Frequency)	Alternative C-1 (Beach Nourishment via Dredged Sources, Annual Frequency)	Alternative C-5 (Beach Nourishment via Dredged Sources, Five-Year Frequency)	Alternative D (Beach Nourishment via Permanent Bypass System)	Alternative E (Submerged Cobble Berm and Beach Nourishment, Annual Frequency)	Alternative F (Beach Nourishment, Annual Frequency with a Mix of Small Natural Stone at the Shoreline) – Preferred Alternative
Park Operations	Minor, long-term, adverse impacts from taking no new actions in the park and continuing with the existing clean sediment beach nourishment in reach 1, resulting in growing workload demands and maintenance operation costs for park staff.	Minor, short-term, adverse impacts from the increased demands that would be placed on park staff and budgets annually. Minor, short-term, beneficial impacts from the resulting reductions in annual cyclic maintenance/restoration work that the park performs.	Moderate, long-term, adverse impacts from the additional planning, execution, and monitoring tasks that would tax employees and operating budgets for approximately 18 months every five years during beach nourishment activities. Minor, long-term, beneficial impacts from reduced cyclic maintenance/restoration demands on park staff and park dollars over each five-year period.	Minor, short-term, adverse impacts from the increased demands that would be placed on staff and budgets each year during the approximate two-month period for beach nourishment activities. Minor, short-term, beneficial impacts from the annual decrease in maintenance/restoration work required by park staff and of park budgets.	Moderate, short-term, adverse impacts from the demands the associated beach nourishment activities would place on park staff and budgets. Minor, long-term, beneficial impacts from the resulting decrease in cyclic maintenance/restoration work performed in the park from the decrease in erosion.	Minor to moderate, short- and long-term, adverse impacts from the additional staff time and operating dollars the associated beach nourishment actions would require, especially the routine monitoring and maintenance of the permanent bypass system for the life of this plan. Minor, short-term, beneficial impacts from the decrease in maintenance/restoration work that would result from the decrease in erosion that would occur from the annual beach nourishment activities.	Minor, short-term, adverse impacts from the increase in park staff responsibilities and the increased demands placed on the park's operating budget during construction of the submerged cobble berm. Moderate, long-term, beneficial impacts from the reduced maintenance demands, reduced restoration demands, and lower operating budgets over the life of this plan.	Minor, short-term, adverse impacts from the increased demands that would be placed on park staff and budgets annually. Minor, short-term, beneficial impacts from the resulting reductions in annual cyclic maintenance/restoration work that the park performs.

Notes:

Short-term: days up to one year.

Long-term: greater than one year.

Additional impacts on the impact topics would result from the proposed management actions specific to the foredune and dune complex (as discussed in "The Alternatives" chapter. The proposed management actions would result in long-term, beneficial impacts as they are intended to improve the ecological quality of the terrestrial environment along Indiana Dunes National Lakeshore.

† The overall acreage or type of wetlands and pannes either within or outside of the project area would not be impacted by the shoreline and beach complex nourishment alternatives listed; rather, impacts on wetlands and pannes as a result of the proposed management actions (as discussed in "The Alternatives" chapter) would be long-term and beneficial.

TABLE 2-4. ALTERNATIVES IMPACTS TABLE, REACHES 3 AND 4

Impact Topic	Alternative A (No-action Alternative)	Alternative C-1 (Beach Nourishment via Dredged Sources, Annual Frequency) – Preferred Alternative	Alternative C-5 (Beach Nourishment via Dredged Sources, Five-Year Frequency)	Alternative D (Beach Nourishment via Permanent Bypass System)
Coastal Processes				
Sediment Transport Process	Minor to moderate, long-term, adverse impacts from the continuation of an overall sediment budget deficit.	Moderate, long-term, beneficial impacts as the sediment budget deficit would be provided from an updrift source, that would more closely mimic natural conditions.	Moderate, long-term, beneficial impacts as the sediment budget deficit would be provided from an updrift source, that would more closely mimic natural conditions.	Moderate, long-term, beneficial impacts as the sediment budget deficit would be provided from an updrift source, that would more closely mimic natural conditions.
Foredune and Dune Formation Process	Moderate, long-term, adverse impacts due to a lack of beach sediment for foredune formation.	Moderate, long-term, beneficial impacts as the sediment placed on the beach would allow for additional sediment supply to create foredunes.	Moderate to major, long-term, beneficial impacts as the additional quantity of material on the beach would foster foredune development.	Moderate, long-term, beneficial impacts as the sediment placed on the beach would allow for additional sediment supply to create foredunes.
Aquatic Fauna	Minor, short-term, adverse impacts as fish would be temporarily displaced due to turbidity, and the benthic communities would be smothered during the placement of sediment. Impacts would be localized to the placement area. Negligible, short-term, adverse impacts as nourishment activities would result in a disrupted environment, which would allow for the introduction/establishment of invasive and nonnative species.	Minor, short-term, adverse impacts as fish would be temporarily displaced due to turbidity. The benthic communities would be temporarily smothered during placement of sediment. Negligible, short-term, adverse impacts as nourishment activities would result in a disrupted environment, which would allow for the introduction/establishment of invasive and nonnative species. Minor, long-term, beneficial effects from reducing erosion in the area and enhancing the fish and benthic habitat.	Moderate to major, short- and long-term, adverse impacts due to the nourishment placement activities. Fish would be displaced, and fish life cycles would be interrupted. The larger footprint of the placement area would result in smothering of the benthic communities along most of reach 3. Negligible, short-term, adverse impacts as nourishment activities would result in a disrupted environment, which would allow for the introduction/establishment of invasive and nonnative species. Minor, long-term, beneficial effects from reducing erosion in the area and enhancing the fish and benthic habitat.	Minor, short-term, adverse impacts as fish would be temporarily displaced due to turbidity. The benthic communities would be temporarily smothered during placement of sediment. Negligible, short-term, adverse impacts as nourishment activities would result in a disrupted environment, which would allow for the introduction/establishment of invasive and nonnative species. Minor, long-term, beneficial effects from reducing erosion in the area and enhancing the benthic and fish habitat.
Terrestrial Habitat	Minor, short- and long-term, adverse impacts from the erosion and destabilization of habitat that would continue from taking no new actions in the park, including any actions to invite or deter invasive and nonnative plants. Taking no new actions in the park would not improve the ability of the beach to withstand storm events and preserve habitat for plants and animals.	Negligible to minor, short-term, adverse effects from re-vegetation that would affect sensitive habitat and as some beach vegetation would be smothered during placement. Minor, short-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion. Negligible to minor, short-term, beneficial impacts since material dredged from the lake bottom would have no or limited viable nonnative invasive plant species seedbank, and from the improved ability of the beach to withstand storm events and preserve terrestrial habitat for plants and animals.	Negligible to minor, short-term, adverse impacts from re-vegetation that would affect sensitive habitats. Moderate, short-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion. Moderate, long-term, adverse effects from the approximate six-month duration of placement activities every five years and the larger placement footprint. Negligible to minor, long-term, beneficial impacts since material dredged from the lake bottom would have no or limited viable nonnative invasive plant species seedbank, and from the improved ability of the beach to withstand storm events and preserve terrestrial habitat for plants and animals.	Negligible, short-term, adverse impacts from re-vegetation that would affect sensitive habitats. Minor, short-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion, and decreased degradation of the beach and consequently the foredune plant communities, resulting in improved terrestrial habitat for native plants and animals to thrive on. Minor, short-term, adverse impacts as some beach vegetation would be smothered during placement. Negligible to minor, short-term, beneficial impacts since material from an updrift location would have no or limited viable nonnative invasive plant species seedbank, and from the improved ability of the beach to withstand storm events and preserve terrestrial habitat for plants and animals.

TABLE 2-4. ALTERNATIVES IMPACTS TABLE, REACHES 3 AND 4

Impact Topic	Alternative A (No-action Alternative)	Alternative C-1 (Beach Nourishment via Dredged Sources, Annual Frequency) – Preferred Alternative	Alternative C-5 (Beach Nourishment via Dredged Sources, Five-Year Frequency)	Alternative D (Beach Nourishment via Permanent Bypass System)
Threatened and Endangered Species and Species of Concern	Moderate, short-term, adverse impacts from continued erosion, loss of habitat for piping plover and Pitcher's thistle, and continued sediment budget deficit. May affect, and is likely to adversely affect piping plover and Pitcher's thistle because development of future habitat is not addressed and substantial erosion would continue. No effect on the Karner blue butterfly, Indiana bat, and eastern massasauga rattlesnake as beach nourishment activities would not affect their habitat.	Moderate to major, short-term, beneficial impacts from the habitat restoration that would result from the expanded beach nourishment activities. Coupled with beach nourishment, dredging would not be an adverse modification to the piping plover habitat. Minor, short-term, adverse impacts as placement of nourishment material would temporarily disturb the ability of piping plover to nest and for Pitcher's thistle to establish. May affect, but is not likely to adversely affect piping plover and Pitcher's thistle as beach nourishment activities would result in habitat restoration. No effect on the Karner blue butterfly, Indiana bat, and eastern massasauga rattlesnake as beach nourishment activities would not affect their habitat.	Moderate to major, long-term, beneficial impacts from the habitat restoration that would result from the expanded beach nourishment activities. Coupled with beach nourishment, dredging would not be an adverse modification to the piping plover habitat. Minor to moderate, short-term, adverse impacts on these species as placement of nourishment material would disturb the ability of piping plover to nest and for Pitcher's thistle to establish. May affect, but is not likely to adversely affect piping plover and Pitcher's thistle as beach nourishment activities would result in habitat restoration. No effect on the Karner blue butterfly, Indiana bat, and eastern massasauga rattlesnake as beach nourishment activities would not affect their habitat.	Moderate to major, short- term, beneficial impacts as habitat loss would diminish and the possibility of the establishment of a natural ecosystem would be likely. Minor, short-term, adverse impacts during placement activities from the temporary disturbance to habitat, and from the visual intrusions being introduced in to the park during construction of the permanent bypass system. Coupled with beach nourishment, a permanent bypass system would not be an adverse modification to the piping plover habitat. May affect, but is not likely to adversely affect piping plover and Pitcher's thistle as beach nourishment activities would result in habitat restoration. No effect on the Karner blue butterfly, Indiana bat, and eastern massasauga rattlesnake as beach nourishment activities would not affect their habitat.
Wetlands and Pannes†	Not applicable (see note below).	Not applicable (see note below).	Not applicable (see note below).	Not applicable (see note below).
Soundscape	Minor, short-term adverse impacts from beach nourishment activities related to sound generated from the equipment grading the nourishment material along the beach.	Negligible to minor, short-term, adverse impacts from sound generated by barges and equipment grading the nourishment material along the beach.	Minor to moderate, short-term, adverse impacts from sound generated by barges and equipment grading the nourishment material along the beach.	Negligible to minor, short-term, adverse impacts from the sound that would be generated from construction and associated operation of the permanent bypass system.
Visitor Experience	Minor to moderate, short- and long-term, adverse impacts from continued temporary beach closings and ongoing degradation of popular visitor amenities from continued shoreline erosion.	Minor, short-term, adverse impacts from the visual intrusions introduced into the park (i.e., barges and grading equipment), and from the annual beach and trail closings that would be required during nourishment activities for safety reasons. Minor, short-term, beneficial impacts from the temporary increase in beach size in reach 3 (resulting in an expanded area for visitor use and enjoyment), and from reductions in the amount of maintenance/ restoration work required from decreased erosion (resulting in fewer beach closings).	Moderate, short-term, adverse impacts from extended beach closings, and from visual intrusions being introduced into the visitors' viewshed (i.e., barges and grading equipment). Minor, short- and long-term, beneficial impacts from the temporary increase in beach size (resulting in an expanded area for visitor use and enjoyment), providing visitors with an expanded area to use and enjoy, and from the reduction in future maintenance/restoration work in the park (which would reduce the number of beach and trail closings).	Minor, short-term, adverse impacts from temporary beach closings, and from the visual intrusions being introduced into the park during construction of the permanent bypass system. Minor, short-term, beneficial impacts from the reduction in future beach closings that would result from less cyclic maintenance and restoration work needing to be performed from reduced erosion, as well as from the temporary increase in beach size (resulting in an expanded area for visitor use and enjoyment). Minor, long-term, adverse impacts from the visual intrusion the pump and lift stations would introduce to the park.
Park Operations	Minor, long-term, adverse impacts from taking no new actions in the park and continuing with the existing clean sediment beach nourishment in reach 3, resulting in growing workload demands and maintenance operation costs for park staff.	Minor, short-term, adverse impacts from the additional demands that would be placed on park staff and park operating budgets to plan and carry out the required actions annually over an approximate two-month period. Minor, short-term, beneficial impacts from the savings and decreased workloads that would result from the reduced maintenance/restoration demands that would come with less shoreline erosion.	Moderate, short-term, adverse impacts from the additional demands that would be placed on park staff and park budgets (for approximately six months every five years) to carry out the actions associated with this alternative. Minor, long-term, beneficial impacts from the reductions in maintenance/ restoration work as the actions associated with this alternative would decrease erosion in the park.	Minor to moderate, short- and long-term, adverse impacts from the additional staff time and operating dollars the associated beach nourishment actions would require, especially the routine monitoring and maintenance of the permanent bypass system for the life of this plan. Minor, short-term, beneficial impacts from the associated erosion decrease and resultant decrease in required maintenance/restoration work by park staff (reducing operating budget drains).

Notes:
Short-term: days up to one year.
Long-term: greater than one year.
Additional impacts on the impact topics would result from the proposed management actions specific to the foredune and dune complex (as discussed in "The Alternatives" chapter. The proposed management actions would result in long-term, beneficial impacts as they are intended to improve the ecological quality of the terrestrial environment along Indiana Dunes National Lakeshore.
† The overall acreage or type of wetlands and pannes either within or outside of the project area would not be impacted by the shoreline and beach complex nourishment alternatives listed; rather, impacts on wetlands and pannes as a result of the proposed management actions (as discussed in "The Alternatives" chapter) would be long-term and beneficial.

CHAPTER 3
Affected Environment

INTRODUCTION

The "Affected Environment" chapter describes existing conditions for those elements of the natural environment that would be affected by the implementation of the actions considered in this *Shoreline Restoration and Management Plan / Draft Environmental Impact Statement* (EIS). The natural environment components addressed include coastal processes, aquatic fauna, terrestrial habitat, threatened and endangered species and species of concern, and wetlands and pannes. Soundscapes, visitor experience, and park operations are also addressed. Impacts for each of these topics are analyzed in the "Environmental Consequences" chapter.

INDIANA DUNES NATIONAL LAKESHORE BACKGROUND

Lake Michigan Geological Setting

Southern Lake Michigan lies within the western half of the Michigan basin, a geologic depression formed as a result of tectonic activity. Since the last glacial retreat began approximately 12,000 years ago, the southern Lake Michigan shoreline has been shaped by the forces of a dynamic environment, including lake level fluctuations, shoreline erosion, and sediment deposition. This glacial retreat, re-advance, and retreat from early Lake Michigan (paleo-Lake Chicago), referred to as the Wisconsin Glacial Episode of the Pleistocene Epoch (Pielou 1991), is responsible for many of today's geologic formations at Indiana Dunes National Lakeshore (Foster and Folger 1994). The geographical features, as such, were created through the interaction of lake recession, Lake Michigan surface winds, and erosion over time.

HYDROGEOLOGIC SETTING

The relationship between groundwater and surface water in the Great Lakes region is one that, while important, is not well understood. In most instances, the natural flow of a stream includes both a surface water runoff component and a groundwater inflow component. The groundwater component comprises most of the drainage into Lake Michigan; it is estimated that approximately 80% of the total annual flow of tributary streams to Lake Michigan originate as groundwater. This water tends to be nearly constant in temperature despite seasonal weather changes, and is therefore vital to ecosystem functions within Lake Michigan and its tributaries (Grannemann 2004). As the groundwater entering Lake Michigan is often a non-point source for contamination (e.g., stormwater runoff), anticipating and effectively managing potentially detrimental water quality issues is unlikely and often outside the capabilities of park staff at Indiana Dunes National Lakeshore.

CLIMATE CHANGE

As previously discussed in the "Purpose and Need for Action" chapter, recent climate change trends in the Indiana Dunes National Lakeshore vicinity include:

- an increase in annual temperatures of 0.25°C per decade
- a progressive advance in the date of the last spring freeze
- increases in autumn precipitation
- doubling of frequencies of heavy rainfall events and an increase in the number of individual rainy days and week-long heavy rainfall events
- increased flooding

- an increase in the number of heat waves and record-high temperatures (Hayhoe *et al.* 2010)

Climate change may have an effect on Lake Michigan coastal processes in the future, though specific effects in the park are difficult to predict. As summer temperatures continue to rise, evaporation has begun to greatly contribute to lake level changes for the first time (since 1980). Scientists believe that the level of Lake Michigan may continue to decrease because of this (USGCRP 1996). Additionally, recent studies of the Great Lakes region indicate that ice cover in the center of the lakes shrank by more than 30% between 1970s and 2002. Through 2009, ice cover across the entire surface of the lakes had fallen 15%. It is projected that Lake Michigan may have some winters with no ice cover in as soon as ten years (Rocky Mountain Climate Organization 2011). Decreasing ice cover would increase the impacts of storms on the nearshore, and on the foredune and dune complex. With reduced winter ice and snow cover, the dunes are afforded less protection against sediment blowing away from the dunes and beach, and against wave action undercutting the shoreline, increasing erosion rates. Conversely, greater wave action would also increase the deposition of sediment in some places, thereby increasing accretion areas and the need for maintenance (Rocky Mountain Climate Organization 2011). The combination of exacerbated erosion and deposition rates would alter the Indiana Dunes National Lakeshore beach profile.

In addition, climate change may have an effect on the native fish assemblages and benthic species in the nearshore environment along Indiana Dunes National Lakeshore. Scientists believe that distribution of fish may change according to the temperature of water. Warm water fish populations are projected to expand northward, while cold water fish populations would decrease, or disappear from the Great Lakes altogether. Increasing temperatures and stronger storm events would disrupt the shallow waters where many fish spawn, threatening population levels of native fish (USGCRP 1996). As fish are forced to move to deeper waters, they may be exposed to increased predation as they would lose the protection afforded by shallower waters. Additionally, higher water temperatures also lead to lower oxygen levels, promoting release of contaminants such as phosphorus and mercury, which become more soluble when oxygen levels decrease. When fish absorb these contaminants, they are a health hazard not only for predatory fish and animals, but also humans that consume them (Rocky Mountain Climate Organization 2011).

Warmer waters may also promote the replacement of native fish species by nonnatives able to thrive in varied or disturbed environmental conditions, as native species are often adapted to a narrower range of conditions that can be disrupted by a changed climate. If, for example, the Asian carp (*Hypophthalmichthys* spp.) established in Lake Michigan, this fish would consume massive amounts of plankton, reducing the food available for native fish (Rocky Mountain Climate Organization 2011). Additionally, zebra mussels add to increased productivity in lakes by outcompeting native species and increasing water clarity that leads to accelerated algae growth (USGCRP 1996).

While scientists expect climate change to have an effect on the park's vegetation, the rate and magnitude of potential modifications are not known. It is known, however, that the growing season in the park has been expanding as spring arrives sooner, and the first freeze is occurring later. Increasing variability of temperature and precipitation are harmful to vegetation and cause diebacks. Additionally, increasing levels of carbon dioxide affect the physiology of vegetation, and may increase the productivity of trees (USGCRP 1996).

Within Indiana Dunes National Lakeshore, climate change is likely to increase the threats posed to natural plant communities by nonnative invasive plants, since invasive plants typically thrive in a wider range of

environmental conditions and can out-compete native plants for water, nutrients, and other plant essentials. A warmer climate would promote the spread of even more invasive plants into the park (Rocky Mountain Climate Organization 2011).

COASTAL PROCESSES

SEDIMENT TRANSPORT PROCESSES

Changes in Lake Michigan water levels have occurred since its formation. These fluctuations in levels affect both natural and manufactured resources. Flooding and shoreline erosion result in property damage, impact wetland acreage, and impact depths of navigation channels. Unusually high lake levels in the 1950s, 1970s, and mid-1980s led to numerous investigations to identify the causes of lake level fluctuations, and potential modifications to the lake system to resolve problems associated with the extreme levels (IDNR Division of Water 1994).

In an uninterrupted system, the amount of sediment erosion or deposition that occurs in any given year at a location along the shoreline is affected by such natural factors as physical configuration of the shoreline, wave approach angle, nearshore circulation, availability of sediment, prevailing wind direction, and seasonal differences in storm intensity. In general, seasonal differences in storm intensity result in a yearly cycle of narrow winter beaches and wide summer beaches. High lake levels and severe storms usually result in the highest erosion rates along unprotected portions of a shoreline (IDNR Division of Water 1994).

Two of the greatest changes to the shoreline at Indiana Dunes National Lakeshore are navigation structures and the existence of engineered peninsulas projecting into the lake, each created primarily for industrial expansion. Approximately 4,053 acres of man-made land was created, surveyed, and is now patented in Lake Michigan (IDNR Division of Water 1994). Such human modifications have interacted with natural shoreline processes over the last century, drastically altering the Lake Michigan shoreline profile and resulting in unstable conditions. Manufactured structures disrupt sediment movement along the shoreline and impede additional supplies of sediment from moving into the system. This interrupted sediment movement has resulted in erosion of the shoreline in some locations and accumulation of sediment in others. Examples of both situations exist within reaches 1 through 4 of Indiana Dunes National Lakeshore (IDNR Division of Water 1994).

Due to a high rate of accretion on the updrift side of the Northwest Indiana Public Service Company (NIPSCO)/Bailly industrial complex, various methods have been employed to maintain the associated shipping canals and the water intake. Maintenance dredging has occurred downdrift of the Port of Indiana industrial complex at Burns International Harbor.

To combat the increasing trend of interruptions to littoral drift, the U.S. Army COE has conducted beach nourishment activities at Crescent Dune, near Mount Baldy, annually since 1974. According to a 2006 study, the average annual background erosion rate for the Great Lakes is approximately 1 meter; the beach at the toe of Mount Baldy is eroding at a rate of approximately 3 meters annually (Przybyla-Kelly and Whitman 2006). In the past 26 years, more than 1.2 million cubic yards of material has been placed at Crescent Dune, and has moved downdrift via natural wave action

(COE, Bucaro, pers. comm. 2011a). Studies conducted since 1985 have shown that sediment placed at the eastern end of the park erodes entirely within two to five years (COE 1986; Horvath *et al.* 1999).

DUNE FORMATION PROCESSES

Foredune development occurs when the lake level remains relatively constant and sediment is deposited, trapped, and held onshore by vegetation. When natural geologic conditions exist, the dynamic nature of the Indiana Dunes National Lakeshore shoreline provides many opportunities for habitat succession. Habitat connectivity and natural shoreline processes are vital to the conservation of the foredune and dune complex at the park. Historically, sediment moved naturally from the beach throughout the foredune complex in the project area, thereby providing a key link between terrestrial ecosystems and coastal processes. As Lake Michigan receded over time, foredunes succeeded into mature, stabilized dune forests. A disruption to one part of the link (e.g., eliminating natural sediment supply), affects the ecological integrity and dynamic stability of the entire foredune and dune complex in the project area.

AQUATIC FAUNA

THE NEARSHORE ENVIRONMENT

For the purposes of this plan, the nearshore area is encompassed by water depths generally less than approximately 9 meters (30 feet). It includes both higher-energy coastal margin areas and lower-energy nearshore open-water areas. Nearshore open-water areas are subject to higher wave energies and associated littoral or nearshore processes during large storm events.

Historically, Indiana Dunes National Lakeshore nearshore waters served primarily as habitat for fish, wildlife, and the aquatic organisms that supported their production. A large number of Lake Michigan fish use the nearshore waters for one or more critical life stages or functions. The nearshore waters are areas of temporary feeding or nursery grounds for some species, a year-round residence for other fish, and migratory pathways for anadromous fish (i.e., fish born in fresh water that spend most of their life in the sea and return to fresh water to spawn).

Fish species diversity and production in the nearshore waters are higher than those in offshore waters and are generally highest in the shallower, more enriched embayments with large tributary systems (Edsall and Charlton 1997). Alterations to river mouths and modifications to the shoreline at Indiana Dunes National Lakeshore have interrupted flow paths and disrupted nearshore coastal processes that create and maintain nearshore habitats. Many native species require relatively shallow, well-oxygenated waters flowing though coarse gravel and cobble substrates with protected interstitial spaces. Spawning areas are often adjacent to nearshore nursery areas, and rely on regional circulation patterns to transport larval fish into adjacent nursery areas.

The nearshore waters are not only habitat for fish, but also for many other species. Nearshore waters are critical feeding and resting habitat for waterfowl such as ducks, geese, and swans, especially during the fall and spring migrations. Aquatic mammals, including muskrat (*Ondatra zibethicus*), beaver (*Castor canadensis*), otter (*Lontra canadensis*), and mink (*Mustela vison*) can be found in some undisturbed, sheltered waters in the lower reaches of tributaries and near coastal wetlands. Great Lakes nearshore waters are critical habitat for threatened or endangered species and species of special concern, including the piping plover (*Charadrius melodus*), bald eagle (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), and freshwater mussels.

NATIVE SPECIES

The southern shoreline of Lake Michigan, specifically along Indiana Dunes National Lakeshore, offers a rare environment within the Midwest region of the country. The sandy substrate of the lakeshore provides for benthic species and fish assemblages intertwined in a delicate food web that is easily disrupted by external forces that include water quality concerns from surrounding industrial discharges, unequal distribution of sediment supply, and the introduction of nonnative species.

MUSKRAT

Meiofauna and Macroinvertebrates

In large oligotrophic lakes like Lake Michigan, abundance of the dominant groups of benthic organisms tends to be directly proportional to the amount of available food; increased amounts of phytoplankton lead to increased amounts of organic material settling to the lake bottom, thereby providing more potential food for macrobenthos (Madenjian *et al.* 2002). In the relatively high wave energy nearshore environment, at certain sediment-starved areas along the shoreline (particularly at the base of Mount Baldy), the clay substrate naturally found beneath the sediment has been exposed, and organic matter often found in calmer waters has been carried away from the shoreline. The kinetic nature of the nearshore environment, coupled with sediment deprivation from anthropogenic influences, has resulted in low-density and diversity within the benthic communities in the project area. One study, conducted from 1996 to 1998 in conjunction with a COE beach nourishment program, showed that relatively few species were detected in the benthic communities inhabiting sandy substrates in the nearshore area (Horvath *et al.* 1999). Benthic species such as roundworm (phylum *Nematoda*), aquatic worm (subclass *Oligochaeta*), seed shrimp (subclass *Ostracoda*), bloodworm (family *Chironomidae*), and copepods (*Calanus hyperboreus*) are among the most common invertebrates identified in the sandy substrates in the project area. Two main invertebrate groups, nematoda and oligochaeta, appear to be most abundant (Przybryla-Kelly and Whitman 2006). Generally, the meiobenthos outnumber the macrobenthos in the nearshore environment (Last *et al.* 1995). A summary of benthic species in the Lake Michigan nearshore is provided in Appendix D: Species List.

A 2004 study of the benthic invertebrate community of southern Lake Michigan was conducted to evaluate the effects of beach nourishment on the nearshore environment (Garza and Whitman 2004). As many of the benthic taxa identified in the Lake Michigan nearshore are part of the detrital food web (National Oceanic and Atmospheric Administration / Great Lakes Environmental Research Laboratory 2009), the increased stability afforded by deeper water may sustain a larger benthic community by allowing for a greater accumulation of organic matter (Garza and Whitman 2004). The study did reveal a notable decrease in mean invertebrate density downdrift from the site of beach nourishment, suggesting that sediment placement affected invertebrate populations. A subsequent study conducted in 2006, however, indicated that the benthos within the nearshore experienced a relatively high rate of recovery within 8 to 12 months after nourishment activities. The densities and total number of benthic taxa increased with depth, suggesting a lower impact of sediment drift and wave action in deeper waters (Przybryla-Kelly and Whitman 2006).

Fish of Lake Michigan

The Indiana Dunes National Lakeshore nearshore waters are key areas for nutrient exchange, and serve as important spawning and nursery habitat for one or more life stages of most Lake Michigan fish. The hard clay outcroppings along the shoreline at the base of Mount Baldy and the cobble/gravel areas in reach 2, are two examples of habitat ideal for fish spawning and nurseries, particularly for yellow perch (*Perca flavescens*). The nearshore area also provides such habitats for smallmouth bass (*Micropterus dolomieu*) and other important fish. Coastal wetland habitats support spawning and early life stages of bass, sunfish, northern pike (*Esox lucius*), walleye(*Sander vitreus*), and yellow perch. Thus, natural and anthropogenic threats (e.g., armoring of shorelines, contamination of water) that degrade or alter any of these habitats severely affect fish-community diversity and relative abundance (Rutherford 2008).

Nearshore fish include recreationally and commercially important species such as yellow perch, walleye, smallmouth bass,

northern pike, catfish, and sunfish, as well as nongame species, including spottail shiner (*Notropis hudsonius*), slimy sculpin (*Cottus cognatus*), mottled sculpin (*Cottus bairdii*), trout perch (*Percopsis omiscomaycus*), and johnny darter (*Etheostoma nigrum*) (Clapp *et al.* 2005).

The yellow perch is a spiny-rayed fish that experiences a diet shift during its life cycle. As young and larval fish, yellow perch feed on microscopic organisms such as zooplankton, but with increasing size, macroinvertebrates (such as midges) comprise a larger portion of their diet. As adults, yellow perch diets include invertebrates, fish eggs, mysid shrimp (*Americamysis bahia*), and other fish such as minnows. Yellow perch are predominantly piscivorous, known in some cases to eat other members of the perch family (Hubbs and Lagler 1964; Bergman and Greenberg 1994). A decline in yellow perch populations in southern Lake Michigan was observed in the 1990s. Declines in prey beginning in the 1980s were noted in conjunction with the introduction of nonnative species such as the zebra mussel, round goby (*Neogobius melanostomus*), and alewife (*Alosa pseudoharengus*).

A summary of fish assemblages historically found in the Lake Michigan nearshore is provided in Appendix D: Species Lists.

INVASIVE AND NONNATIVE SPECIES

Background

Nearshore and coastal waters have provided habitat for the 184 nonnative species introduced to the Great Lakes since 1840. These habitats have been profoundly altered by nonnative species, with effects ranging from uprooting of wetland plants by common carp, to the creation of microhabitats by dreissenid mussels. The status of the Great Lakes nearshore waters with respect to nonnative and invasive species is poor. Since 1996, 18 new nonnative species have been discovered; a rate of 1.5 per year. This rate is higher than the long-term discovery rate (1.1 per year since 1840), though lower than the rate since the opening of the St. Lawrence Seaway in 1959 (1.8 per year). Despite a slightly lower discovery rate in the last 15 years, an increase in the number of nonnative species in the Great Lakes represents a deteriorating trend as additional nonnative and invasive species indicate further disruption of existing food webs, often in unpredictable and/or undesirable ways (Holeck *et al.* 2009).

Deteriorating conditions in the shallow water near the coastal zone is a fairly common theme in Lake Michigan. In general, for the last several decades offshore conditions have been improving, whereas nearshore conditions have worsened and/or failed to show sustained improvement (Mason 2009). Key invasive species identified in the Indiana Dunes National Lakeshore project area are discussed below.

Zebra and Quagga (*Dreissenid*) Mussels

Zebra mussels were first documented in Lake Michigan in 1989 and rapidly increased in nearshore rocky habitats. Quagga mussels were first documented in Lake Ontario, and were identified in Lake Michigan by 1997 (Detmers *et al.* 2008). Quagga mussels have greatly expanded their range in Lake Michigan since the early 2000s, and have replaced zebra mussels in many areas (Pothoven *et al.* 2009). Both zebra mussels and quagga mussels are natives of the Ponto-Caspian region, and are thought to have invaded the Great Lakes via ballast water.

Zebra mussels have the ability to filter water, allowing sunlight to penetrate to greater depths, potentially resulting in additional growth of algae blooms. These dreissenid mussels also may be partially responsible for the lack of improvement in nearshore water quality despite distinct improvements in offshore waters from the decline in phosphorus loadings. Some researchers

suggest that dreissenids sequester phosphorus in nearshore areas through their filtering activity and through deposition of mucus covered pseudofeces (Holeck *et al.* 2009).

Dreissenid mussels compete directly with zooplankton for food because they filter phytoplankton from the water column. Since dreissenid mussels invaded Lake Michigan, zooplankton densities, when first-feeding of yellow perch larvae occurs, have declined, indirectly resulting in reduced numbers of age-0 yellow perch in the fall. It has been hypothesized that the recent decline in Diporeia (*Diporeia* spp.) populations in southern Lake Michigan is another apparent indirect effect of dreissenid mussels. This decline is relevant to the health of nearshore fish as Diporeia is an energy-rich food source and an important prey for several fish, including alewife, yellow perch, and slimy sculpin (Detmers *et al.* 2008).

Round Goby

The round goby is indigenous to the Black, Azov, and Caspian Seas (Kuhns and Berg 1999). This invader was first reported in Lake Michigan in 1993 and is an aggressive species that feeds on lake-bottom or benthic fish.

It has been suggested that round gobies have exerted both positive and negative impacts on the nearshore fish community. Despite a nearshore environment exhibiting a change in species composition as a result of invasive species, fish such as the yellow perch have been able to adapt their diet and respond positively by making round gobies a new food source for adult yellow perch (Truemper *et al.* 2006). Conversely, negative impacts from consumption of round gobies are also likely. Round gobies greater than 50 millimeters in length consume dreissenid mussels, and because of this, biomagnification of toxic substances (e.g., polychlorinated biphenyls and polychlorinated naphthalene) through the food web is likely. Additionally, round gobies have essentially eliminated important nearshore fish, including the mottled sculpin and johnny darter (Truemper *et al.* 2006; Detmers *et al.* 2008).

Potential Future Invasive and Nonnative Species in Lake Michigan

Other potential invaders may arrive during the next few years because of the high rate of commercial, industrial, and recreational use of Lake Michigan, particularly in areas adjacent to Indiana Dunes National Lakeshore. Of special concern is the possibility that silver carp (*Hypophthalmichthys molitrix*) and/or bighead carp (*Hypophthalmichthys nobilis*), collectively known as Asian carp, would enter Lake Michigan through the Chicago Sanitary and Ship Canal (CSSC), the live food trade, or other means. Three electric dispersal barriers were constructed by the COE in the CSSC to deter the interbasin transfer of invasive nonnative fish species between the Mississippi River and the Great Lakes basins. The barriers are formed of steel electrodes secured to the bottom of the CSSC, creating an electric field in the water to discourage fish from crossing (COE 2011b). Similarly, efforts among U.S. and Canadian agencies and legislative bodies are seeking to eliminate trade of live Asian carp (Detmers *et al.* 2008).

The northern snakehead (*Channa argus*) is another potential invader. This species escaped into the Potomac River basin, most likely from aquarium releases. Specimens have been collected by the Wisconsin Department of Natural Resources and the Michigan Department of Natural Resources from the non-Great Lakes waters of these states. One snakehead was collected by an angler while fishing in a Chicago harbor in October 2004. Based on an intensive sampling effort in the harbor, best estimates suggest that this snakehead was released from an aquarium and is not part of an established population. However, additional monitoring of Chicago harbors would continue to provide critical early warning signs. Other fish that would rise to pest status if they do establish in the Great Lakes include tyulka (*Clupeonella cultriventris*), Eurasian minnow (*Phoxinus*

phoxinus), Black sea silverside (*Atherina* spp.), European perch (*Perca fluviatilis*), and monkey goby (*Neogobius fluviatilis*) (Detmers *et al*. 2008).

TERRESTRIAL HABITAT

The park is within the Indiana natural region categorized as the Lake Michigan Natural Region and the Northwestern Morainal Natural Region (see Map 3-1). As shown on Map 3-1, the Lake Michigan Natural Region is entirely aquatic, comprised solely of Lake Michigan (Homoya 1985). The terrestrial portion of the project area is situated within the Northwestern Morainal Natural Region; specifically, within the Lake Michigan Border section and the Chicago Lake Plain section of this natural region.

The Lake Michigan Border section represents a narrow band immediately adjacent to Lake Michigan. It is the youngest of the morainal complexes in Northwest Indiana, representing a discontinuous dune ridge (Greenberg 2002). Beach, foredune, high dunes, and pannes are the most common natural communities within this section, with sand as the most common substrate (calcareous sand in pannes) and muck in interdunal depressions. The Chicago Lake Plain section is located farther from the lake, south and southeast of the Lake Michigan Border section, and is characterized by ridge-and-swale and lacustrine plain topography on mostly acidic sand substrates. The natural communities found most commonly in the Chicago Lake Plain section include marsh, lake, sand savanna, sand prairie, and swamp, while forests make up a less common portion of this section (Homoya 1985).

The onshore boundary of the project area encompasses portions of the dune complex and the entirety of the foredune complex within the authorized boundary of the park. The latter constitutes three distinct community types: beach, foredune, and blowout (Wilhelm 1990).

NATIVE PLANT COMMUNITIES

The park contains a great diversity of plant communities and plant species because of the influence of, and proximity to, Lake Michigan and the intersection of the prairie, boreal, and deciduous forest biomes. Littoral drift and sediment deposition have created beach ridges of various complexities, which have resulted in a concentration and juxtaposition of a wide range of natural communities (Greenberg 2002). Many plant species in the park are of conservation concern as they are located at the edge of their geographical ranges.

BEACH PEA

Foredune Complex

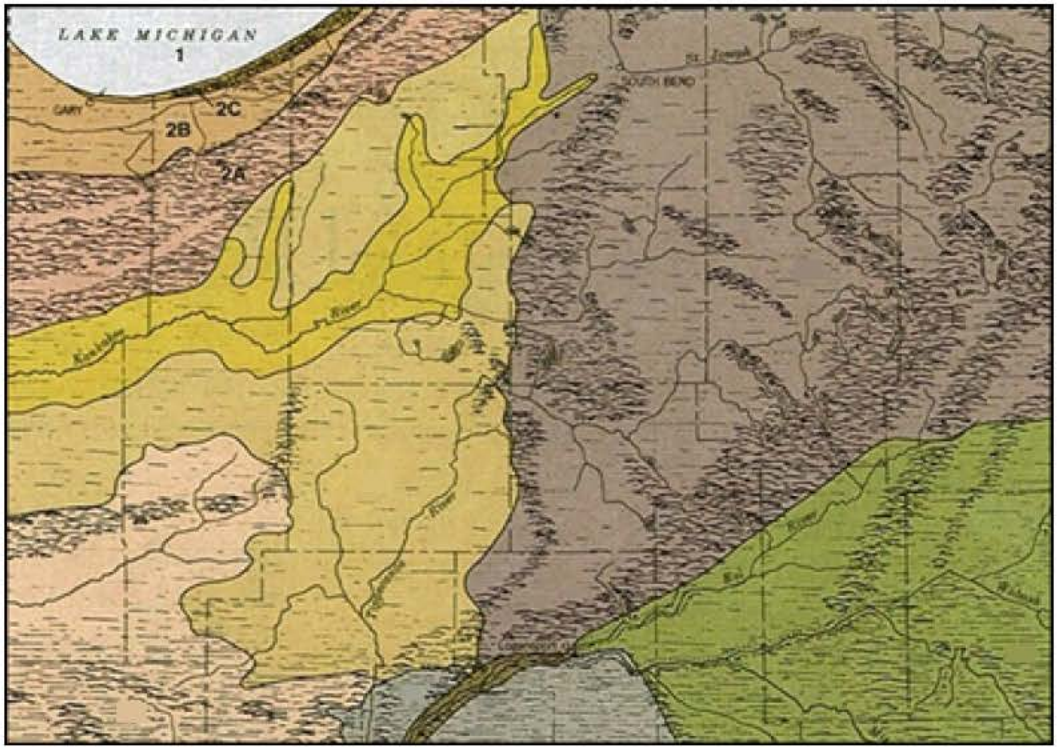
The physiography of the foredune complex is most directly influenced by natural erosion, sediment deposition, and winds produced by Lake Michigan (IDNR 2011). Three plant communities (beach, foredune, and blowout) are found within the foredune complex in the project area.

Beach Community. The beach plant community at Indiana Dunes National Lakeshore constitutes a narrow band that extends from the swash zone, the zone of wave action on the beach, to the farthest reach of storm waves. This area is also demarcated by the edge of Lake Michigan and the first line of dunes (Homoya 1985). It is influenced by wave action and shoreline dynamics and therefore, is constantly in flux. Plant species begin to colonize in the area just outside the influence of the swash zone and normal wave action. Characteristic beach plants are well adapted to the relatively harsh environmental conditions of the shoreline. American sea rocket (*Cakile edentula*) is the "vanguard of beach vegetation" (Swink and Wilhelm 1994) and today serves as one of the primary indicators of this distinct plant community. Other characteristic pioneer species of the beach plant community include American beachgrass or marram grass (*Ammophila breviligulata*), field wormwood (*Artemisia campestris* ssp. *caudata*), American bugseed (*Corispermum americanum*), and winged pigweed (*Cycloloma atriplicifolium*) (Homoya 1985; Swink and Wilhelm 1994). In addition to these beach colonizers, populations of silverweed cinquefoil (*Argentina anserine*) (an Indiana threatened species), seaside spurge (*Chamaesyce polygonifolia*)(an Indiana rare species), and beach pea (*Lathyrus japonicus* var. *maritimus*) (an Indiana endangered species) are rarely seen along the beach anymore.

Foredune Community. Foredunes are relatively small and sublinear in structure. If conditions allow, foredunes develop at the upper edge of the beach community and represent the first line of landward dune development (Wilhelm 1990). The foredune community in the project area is ranked as globally vulnerable (G3) and critically imperiled (G1) in the State of Indiana (IDNR 2011).

Foredune development is currently most active within the accretion zones in the project area along the Indiana shoreline, especially near Miller and West Beach. Foredunes generally increase in size moving from west to east (Wilhelm 1990). The foredune community intergrades with the beach community but is somewhat more stable than the latter due to the presence of established vegetation (Homoya 1985).

PITCHERS THISTLE



Legend

1. Lake Michigan Natural Region

2. Northwestern Morainal Natural Region
   - A. Valparaiso Moraine Section
   - B. Chicago Lake Plain Section
   - C. Lake Michigan Border Section

MAP 3-1
MAP OF THE NATURAL REGIONS OF INDIANA CROPPED TO SHOW NORTHWEST INDIANA

Indiana Dunes National Lakeshore
Shoreline Restoration and Management
Plan / Environmental Impact Statement

National Park Service / U.S. Department of the Interior

March 2012

Source: Hoyoma et al. 1997

American beachgrass is the primary colonizer of these embryonic dunes, and effectively stabilizes and traps windblown sediment. Other key foredune indicator species include but are not limited to the following: bearberry (*Arctostaphylos uva-ursi*), field wormwood, prairie sand reed (*Calamovilfa longifolia* var. *magna*), red-osier dogwood (*Cornus sericea*), Canada wild rye (*Elymus canadensis*), common juniper (*Juniperus communis* var. *depressa*), beach pea, jack pine (*Pinus banksiana*) (state rare), eastern cottonwood (*Populus deltoides*), fragrant sumac (*Rhus aromatica* var. *arenaria*) (state rare), heartleaf willow (*Salix cordata*) (state threatened), little bluestem (*Schizachyrium scoparium*), and Deam's goldenrod (*Solidago simplex* var. *gillmanii*) (state threatened) (Homoya 1985; Wilhelm 1990). Although now largely confined to blowouts, Pitcher's thistle (*Cirsium pitcheri*) historically occupied foredunes (FWS 2002). The number of species of conservation concern that are representative of the foredune plant community are an indication of the rarity of this plant community in the project area.

Blowouts. Blowouts found within the foredune complex are formed by wind action or some other disturbance mechanism. Species found within the beach-foredune complex, including blowouts, depend on a "dynamic microhabitat for their persistence in the dune flora" (FWS 2002). Stabilized foredunes in the project area are dominated by perennials (such as American beachgrass) and often contain at least some tree or shrub species. Conversely, the early successional stages of blowouts have an affinity towards annual, biennial, and short-lived perennial species (Wilhelm 1990). Hence, the short-lived Pitcher's thistle, which lives up to approximately seven years and dies shortly after flowering (FWS 2002), is found within this community. Other vascular plant species common in blowouts include lyrate rockcress or sand cress (*Arabis lyrata*), common milkweed (*Asclepias syriaca*), prairie sand reed, American bugseed, Canada wild rye, flowering spurge (*Euphorbia corollata*), little bluestem, and purple sand grass (*Triplasis purpurea*) (Wilhelm 1990). As blowouts stabilize, the vegetation within them becomes dominated by more long-lived perennial species including bearberry, American bittersweet (*Celastrus scandens*), seaside spurge, red-osier dogwood, common juniper, eastern cottonwood, sand cherry (*Prunus pumila*), heartleaf willow, eastern poison ivy (*Toxicodendron radicans*), and riverbank grape (*Vitis riparia*). The blowout communities thus begin to become indistinguishable from the foredune community (Wilhelm 1990). The largest concentration of blowouts along southern Lake Michigan is located within Indiana Dunes National Lakeshore. See Figure 3-1: Sensitive Habitats, for general locations of blowout communities.

Dune Complex

The dune complex includes a successionally advanced stage of foredunes that consists primarily of savanna and forest (Homoya 1985; Wilhelm 1990). Plant communities present within the dune complex include later successional foredunes, savanna, and small pockets of mesophytic forest; however, the primary components of the dune complex are the stabilized dune forest community and the lee side dune forest (Wilhelm 1990). The high dunes of Indiana are often irregular dune ridges produced by prevailing northerly winds. High dunes in the Mount Baldy vicinity of the project area tend towards mesic habitat dominated by northern red oak (*Quercus rubra*) and white oak (*Quercus alba*). Black oak (*Quercus velutina*) becomes more dominant as one moves west along the shoreline, especially near the Miller and West Beach units in the project area.

Stabilized Dune Forest. The stabilized dune forest community in the project area is located leeward of the foredune complex and is slightly more mesic (due to the greater availability of moisture) than the very similar leeside dune forest community (Wilhelm 1990). This community and the leeside dune forest community are often difficult to

differentiate from the savanna and foredune communities with which they intergrade (Wilhelm 1990). Characteristic plant species in the stabilized dune forest community include red maple (*Acer rubrum*), American columbine (*Aquilegia canadensis*), roundleaf harebell (*Campanula rotundifolia*), flowering dogwood (*Cornus florida*), roundleaf dogwood (*Cornus rugosa*), eastern white pine (*Pinus strobus*), hairy Solomon's seal (*Polygonatum pubescens*), common hop tree (*Ptelea trifoliata* var. *mollis*), and northern red oak (Wilhelm 1990). Historically, the dune complex has been dominated by black oak, white pine, and jack pine (Whitman 1997).

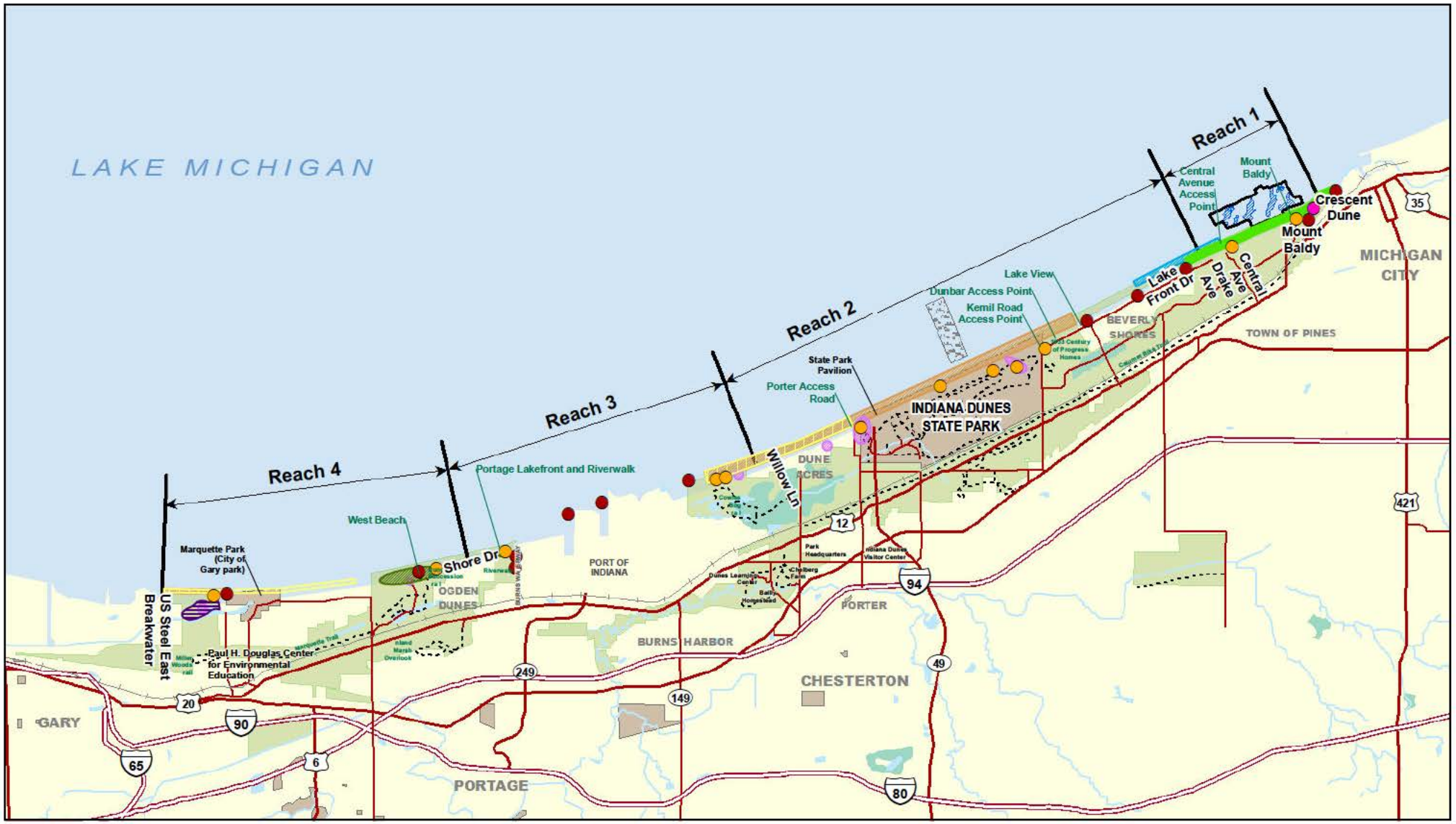
Leeside Dune Forest. The leeside dune forest community is similar to the stabilized dune forest community in the park but is not quite as mesic, and the two communities often intergrade. Vascular plants characteristic of the leeside dune forest include downy serviceberry (*Amelanchier arborea*), smooth yellow false foxglove (*Aureolaria flava*), autumn coralroot (*Corallorrhiza odontorhiza*), white ash (*Fraxinus americana*), hairy bedstraw (*Galium pilosum*), eastern teaberry (*Gaultheria procumbens*), Indian pipe (*Monotropa uniflora*), tall rattlesnake root (*Prenanthes altissima*), white oak, and showy goldenrod (*Solidago speciosa*) (Wilhelm 1990).

Mesophytic Forest. Pockets of mesophytic forest are rarely encountered within the dune complex at Indiana Dunes National Lakeshore and have likely arisen as a result of a lack of fire in this area. These moist pockets are characterized by sugar maple (*Acer saccharum*), bristleleaf sedge (*Carex eburnea*), white ash, American witchhazel (*Hamamelis virginiana*), eastern hop hornbeam (*Ostrya virginiana*), American ginseng (*Panax quinquefolius*), northern red oak, wreath goldenrod (*Solidago caesia*), American basswood (*Tilia americana*), and mapleleaf viburnum (*Viburnum acerifolium*) (Wilhelm 1990).

INVASIVE AND NONNATIVE PLANT COMMUNITIES

The National Park Service defines nonnative invasive plant species as "a species occurring in a given place as a result of direct or indirect, deliberate, or accidental actions by humans." More than 300 different species of nonnative plants have been documented at the park. Resource managers have to contend not only with current threats posed by invasive plant species, but also with emerging ones. The encroachment of nonnative species, particularly invasive plants, is a substantial problem that affects all habitats within the project area. The National Park Service has developed a prioritization plan to protect certain rare and ecologically sensitive units within the park, including pannes. Priority is currently given to newly detected species, small and more easily managed invasive plant populations, and highly invasive plant species (NPS 2011d).

Although numerous nonnative plant species are found throughout the project area, some possess a tremendous propensity to invade natural areas. Sand ryegrass (commonly referred to as lyme grass) (*Leymus arenarius*), yellow sweet clover (*Melilotus officinalis*), spotted knapweed (*Centaurea maculosa*), as well as several nonnative, invasive trees pose ecological threats to the beach and foredune plant communities. Common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*) and hybrid cattail (*Typha* x *glauca*) have already invaded numerous wetland areas, and pose the most substantial threat to pannes. Baby's breath (*Gypsophila paniculata*) is an emerging threat and invades open dune habitats, such as blowouts. Left unchecked, Baby's breath would easily displace Pitcher's thistle and other species of special concern.



Legend

- Blowouts
- Invasives Aquatics/Terrestrial
- Wetlands
- Foredune Restoration
- Active Foredune Development
- Interdunal Wetlands
- Pannes
- Fish Habitat
- Piping plover
- Pitcher's thistle
- Gravel, Muddy Gravel
- Yellow Perch Spawning Habitat
- Limits of Spawning Habitat

N

6,000 0 6,000

Feet

1 inch = 12,000 feet

Gravel Area Reference:
Foster, David S., and Folger, David W., 1994.
The Geologic Framework of Southern Lake Michigan.
Journal of Great Lakes Research, Volume 20.

FIGURE 3-1
SENSITIVE HABITATS
Indiana Dunes National Lakeshore
Shoreline Restoration and Management
Plan / Environmental Impact Statement

National Park Service / U.S. Department of the Interior
March 2012

Garlic mustard (*Alliaria petiolata*) and nonnative bush honeysuckle (*Lonicera* sp.) easily invade the understory of the dune complex in the project area, and are found throughout reaches 1 through 4. Numerous invasive trees, such as tree of heaven (*Ailanthus altissima*), Siberian elm (*Ulmus pumila*), and black locust (*Robinia pseudoacacia*) are found throughout the foredune and dune complex in the project area. Oriental bittersweet (*Celastrus orbiculatus*), one of the most highly invasive vines found in the upper Midwest, is located throughout the dune complex. It has the propensity to invade open areas of the foredunes.

TERRESTRIAL INVERTEBRATES, BIRDS, AMPHIBIANS AND REPTILES, AND MAMMALS

Terrestrial Invertebrates

There are perhaps thousands of species of terrestrial invertebrates that have the potential to occur at the park. Many species of invertebrates that have the potential to occur are either unknown to science or poorly understood. Anecdotal evidence suggests that the park is home to many distinct species of invertebrates that reside in specific habitats. Tiger beetles (*Cicindela ocellata rectilatera*), for example, are as diverse as the habitats in which they reside. Some beetles are found solely in the mature dune forests, while others may only be found in the foredune complex in the park (Daniel 1984).

Birds

Lake Michigan and its nearshore offer both respite and important habitat for numerous resident and migratory bird species. Well over 300 different species of birds have been observed in the nearshore and dune complex at the park (Brock 2011). More than 100 species are regular nesters at the park, and 24 more species were formerly known to nest in the area. The habitat suitability and location of the park are critically important for migratory birds. As Brock (1997) stated, "The shores of this enormous lake provide leading lines that control flight paths of migrants, and the vast open water draws legions of transitory and wintering birds." Lake Michigan itself and the associated beach habitat provide two rare, albeit vital, habitats for avian species. The nearshore provides habitat for open water species (i.e., bay and sea ducks) and the beach and foredune complex provide resting and feeding habitat for shorebirds. In the fall, legions of migratory birds, including rare periodic migrants, are "funneled" to the park. The variation in habitats at the park provides many species of birds a place to rest during migration and provides habitats that are rare in the Midwest (Brock 1997).

Amphibians and Reptiles

The abundance and concentration of different types of habitat within the park make it an important area for amphibians and reptiles in the Midwest. Amphibians require water to breed and the park provides many wetland habitats such as pannes, marshes, bogs, swamps, streams, vernal pools, and ponds for different species to use. The wetland habitat at Indiana Dunes National Lakeshore provides for a high concentration of amphibian and reptile species to occur within the park, which is not typically observed in other regions.

The park has up to 49 different species of amphibians and reptiles: 19 species of amphibians (eight salamander and 11 frog species) and 30 species of reptiles (nine turtle, 18 snake, and three lizard species) (Minton 2001). Even though there is a diverse group of amphibians and reptiles at the park, many populations are declining in number. This is in large part due to habitat degradation, environmental pollution, wetland loss, and hydro-modification of stream systems.

Mammals

Most mammal species move across many habitats during their daily and seasonal activities and likely use many of the unique habitats that occur at the park. Some small mammal species are specific to certain habitats and the juxtaposition of prairie, wetland, forest, and urban/disturbed habitats creates opportunities for many small mammals to occur within the park. Furthermore, with an abundance of small mammal species, predator populations that prey on small mammals can be maintained in the park ecosystem.

Thirty-seven species of mammals are known to occur at the park, with an additional five species not found but likely to occur. Nine mammal species have been extirpated from Indiana and from the park in the past 150 years: porcupine (*Erethizon dorsatum*), gray wolf (*Canis lupus*), red wolf (*Canis rufus*), black bear (*Ursus americanus*), fisher (*Martes pennant*), mountain lion (*Felis concolor*), lynx (*Lynx lynx*), elk (*Cervus elephus*), and bison (*Bos bison*). Some species have moved into the park area or have become more abundant in the last 150 years, such as coyote (*Canis latrans*) and raccoon (*Procyon lotor*). White-tailed deer (*Odocoileus virginianus*) were extirpated early from the park and later the rest of Indiana, but were reintroduced to Indiana in 1935 and are now prolific throughout the state (Whitaker 1994).

THREATENED AND ENDANGERED SPECIES AND SPECIES OF CONCERN

The unique environment at the park provides a mosaic of habitats for terrestrial plants and wildlife in a relatively small area. The park is located between the eastern deciduous forest, tall grass prairie, and Lake Michigan, creating a variety of soils and landscape features caused by the juxtaposition of all of these larger natural regions (Homoya 1985). Plant and wildlife diversity benefit from the variety, juxtaposition, and concentration of habitats. Many animal species spend different life stages in different habitats. In addition, the microclimate of the park varies considerably due to the effects of Lake Michigan. As a result, species such as bearberry, boreal relic, and prickly pear cactus (a southwestern relic), and other disparate floral elements are able to flourish in proximity to each other.

Approximately 130 plant species of conservation concern in Indiana, one federally threatened plant species (Pitcher's thistle), and one federally endangered butterfly (Karner blue butterfly [*Lycaeides melissa samuelis*]), have been documented at the park (NPS 2011d). The Eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*), a candidate for federal listing, is documented at the park. The Indiana bat (*Myotis sodalis*), a federally endangered species, has been found at the Heron Rookery Unit of the park, but is unlikely to be found in or adjacent to the project area because the beach and dunes do not provide suitable habitat. Critical habitat for the piping plover, a federally endangered bird species, has been designated along the shoreline between the NIPSCO / park boundary at the Dune Acres / Cowles Bog Unit next to Kemil Road at Beverly Shores, including Indiana Dunes National Lakeshore; this critical habitat is currently not known to be utilized for nesting but has been used during migration. Figure 3-1: Sensitive Habitats, shows general locations of sensitive habitats in the park. Unfortunately, numerous species have been extirpated over the last century, and many others are now declining or listed as endangered, threatened, or rare (see Appendix D: Species Lists).

VASCULAR PLANTS

The park supports an unusually high concentration of biodiversity, and therefore supports many globally and state important plant species. The park ranks near the top for parks in plant diversity within NPS lands. Scientists have documented more than 1,130 native vascular plants at the park (Yatskievych 2011). The Indiana Department of Natural Resources (IDNR) (2011) reports that 30% of Indiana's listed rare, threatened, endangered, and special concern plant species are known to occur at the park. There are more than 10 state-listed species found within the foredune complex of the project area. Pannes in the project area are even more diverse, with more than 200 different vascular plant species, of which 17 are listed as state endangered (see Appendix D: Species Lists).

Pitcher's Thistle

Pitcher's thistle is federally threatened and is one of the few plants endemic to post-Wisconsin glacial episode Great Lakes sand dunes. Populations of Pitcher's thistle indicate healthy dune ecosystems. Pitcher's thistle typically grows on foredunes with sparse vegetation. Six populations are located within the Indiana Dunes National Lakeshore (see Figure 3-1: Sensitive Habitats). The loss of foredune populations is largely attributable to the disruption of natural shoreline erosion processes and anthropogenic influences. Historically, populations were probably maintained in part by seed dispersal from adjacent foredune and blowout populations. The age at which Pitcher's thistle reproduces varies with environmental conditions, including drought, but generally ranges from five to eight years, although 10 to 12 years have been recorded (FWS 2005). Therefore,

disturbance and foredune erosion must be frequent enough to prevent succession and species loss, but not so frequent as to limit juveniles from reaching maturity (FWS 2002). Such a disturbance regime refers to a dynamically stable foredune complex (such as that witnessed in reaches 2 and 4 of the project area).

In Indiana, Pitcher's thistle colonizes in several of the blowouts in the project area. In these systems, seed dispersal from remaining blowout refugia (isolated or relict populations) would not disperse quickly to all dune habitats due to the distance between suitable habitats. Blowouts that lose self-sustaining populations are less likely to be re-colonized than areas in the more intact, continuous dune complexes. Instead, dune building relies on natural shoreline processes that increase sediment supply. The physical structure of foredunes is an important consideration in determining the habitat suitability and restoration of the Pitcher's thistle. Plants require approximately 70% open sand for successful seedling establishment and survival (FWS 2002). Populations of Pitcher's thistle would be further compromised in the park if blowouts undergo natural succession into another plant community, increasing total plant cover of open sediment. In addition, remaining thistle populations would be further impacted by human trampling and other anthropogenic influences.

TERRESTRIAL INVERTEBRATES

Karner Blue Butterfly

The Karner blue butterfly was historically found in 12 states from Minnesota to Maine but is now only found in seven states, including Indiana. The populations at the park are relatively small and are most threatened by habitat degradation and fragmentation. Wild lupine, or sundial lupine (*Lupinus perennis* L.), is the butterfly's only source of larval food. Isolated lupine populations are found in the dune complex. The reproduction of the butterfly depends on the abundance of lupine and nectar plant species. The park has a variety of savanna and savanna-like habitat in the dune complex, providing butterfly preferred habitat. The adults feed on the nectar of a variety of wildflowers and can be found in both wetlands and uplands at the park (FWS 2003b).

A population of Karner blue butterflies at West Beach is within the project area, and the Miller Woods population is adjacent to the project area, but the remaining populations are further inland and not included within the project area.

KARNER BLUE BUTTERFLIES

BIRDS

Piping Plover

Piping plovers are federally endangered. They breed and raise their young on sparsely vegetated beaches, cobble pans, and sand spits of glacially formed sand dune ecosystems along the Great Lakes shoreline. In similar context to Pitcher's thistle, piping plovers serve as an indicator of a healthy beach and foredune complex. Unfortunately, beach and foredune degradation is pervasive throughout the Great Lakes basins, and has reduced overall habitat suitability for many shoreline birds, including piping plovers. Human disturbances and contaminants, in addition to the genetic and geographic consequences of small population size, pose additional threats.

Historical nesting has occurred at the park, but no breeding populations have recently been documented (FWS 2003a) even though segments of the shoreline demonstrate physical characteristics suitable for piping plover breeding (see Figure 3-1: Sensitive Habitats). Critical habitat for the piping plover has been designated along the shoreline between the NIPSCO / park boundary at the Dune Acres / Cowles Bog Unit next to Kemil Road at Beverly Shores.

While transient individuals have been observed within the project area on an annual basis, anthropogenic influences, such as recreational beach activity at the park, may discourage re-establishment of breeding piping plover populations (FWS 2003a).

Bald Eagle

The bald eagle has been delisted under the Endangered Species Act, but the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act continue to afford the bird protection. The Bald and Golden Eagle Protection Act, passed in 1940, provides for the protection of the bald eagle and the golden eagle (*Aquila chrysaetos*) by prohibiting the take, possession, sale, purchase, barter, offer to sell, purchase or barter, transport, and export or import of any bald or golden eagle, alive or dead, including any part, nest, or egg, unless allowed by permit. "Take" includes pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb. The Migratory Bird Treaty Act is a federal law that carries out the U.S.'s commitment to four international conventions with Canada, Japan, Mexico, and Russia. Those conventions protect birds that migrate across international borders. The Migratory Bird Treaty Act prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests except as authorized under a permit (FWS 2005).

Bald eagles currently do not nest at the park, but the population in Indiana and other Great Lakes states has been increasing, so they could nest in the park area in the future, since suitable habitat is available.

AMPHIBIANS AND REPTILES

Eastern Massasuaga Rattlesnake (*Sistrurus catenatus catenatus*)

The Eastern massasuaga rattlesnake is now a candidate for federal threatened or endangered listing. Historically, the massasuaga rattlesnake was found from central New York to eastern Iowa, and from southern Ontario to southern Illinois and Missouri (Minton 2001). In the past, the elusive rattlesnake was found at the park in greater numbers but may have become rare due to habitat degradation. The massasuaga rattlesnake prefers a variety of wetlands but can be found in upland habitats if prey species become scarce or thermoregulatory requirements must be satisfied. The massasuaga rattlesnake is found in high quality wetlands in the spring and fall, and may move to more upland sites in the summer. In the winter, they hibernate in small mammal burrows, crayfish holes, vegetation hummocks, or tree root masses near the water table (Glowacki 2005). Individuals have been observed within suitable habitats inland from the project area, although sightings are rare.

MAMMALS

Indiana Bat

The Indiana bat is federally listed as an endangered species mostly due to loss of habitat. This bat species ranges over most the eastern U.S. from New England, excluding much of the Atlantic Coast, to the Mississippi Valley, including most of the Midwest (FWS 2007a). During hibernation, Indiana bats form large groups of thousands of individuals. In the spring, females migrate to summer maternity colonies in dead or dying trees with exfoliating bark while males migrate to bachelor colonies. During the summer residency, the females give birth to their

young and raise them until they are able to fly. In the fall the newly volant young (able to fly) and adults migrate back to hibernacula or hibernation areas where mating takes place during fall swarming (Whitaker 1998). Roosting activities have been observed around dead cottonwood trees with loose peeling bark. Deciduous forest edges also provide viable habitat for foraging activities (Whitaker 1994). Habitat loss and urbanization are largely responsible for population declines throughout the region (Sparks 2005). Indiana bats have been found within the Heron Rookery Unit of the park but not within the project area, where suitable habitat is unlikely to be present.

WETLANDS AND PANNES

There are two wetland features specific to the park and the project area. These include the aquatic and panne communities. The aquatic areas include a wetland plant community which is exposed to water year-round. The plants are largely submersed, or the plants have stems topped by leaves and flowering parts extending to the water surface. The substrate may be sandy, gravelly, or mucky. The pannes are intradunal wetlands found in proximity to the shoreline, usually just behind the first or second set of dunes (Homoya 1985). Pannes are seasonally inundated areas where the substrate may be sandy or may comprise marl formed by an accumulation of calcium carbonate produced by the alga stonewort (*Chara* spp.) when inundated for long periods of time. Further discussion follows.

AQUATIC COMMUNITIES

The aquatic community tends to be wet most or all of the year and grades into the slightly drier marsh community. Common vascular plants found in the aquatic community in the Indiana Dunes National Lakeshore project area include: watershield (*Brasenia schreberi*), coontail (*Ceratophyllum demersum*), yellow pond lily (*Nuphar lutea* ssp. *advena*), American white water lily (*Nymphaea odorata* ssp. *tuberosa*), colored swampweed (*Polygonum amphibium* var. *emersum*), pickerel weed (*Pontederia cordata*), grassy pondweed (*Potamogeton gramineus*), Illinois pondweed (*Potamogeton illinoensis*), small pondweed (*Potamogeton pusillus*), and common arrowhead (*Sagittaria latifolia*) (Wilhelm 1990).

PANNES

Pannes are distinct calcareous, sand-based, intradunal wetlands found close to the shoreline, usually just behind the first or second set of dunes as one moves away from Lake Michigan (Homoya 1985). Naturally occurring pannes are extremely rare in the Great Lakes region, and are considered globally imperiled and critically imperiled in the State of Indiana. In addition, pannes are nutrient poor, with vegetation suggestive of a fen (Homoya 1985). Rhizomatous sedges such as smooth sawgrass (*Cladium mariscoides*) provide the dominant cover type (Chicago Wilderness 1999). There is a total of 20 pannes located within the project area. The largest concentration of naturally occurring pannes is located within reach 4 at West Beach. One isolated panne is located just east of Mount Baldy.

Despite their rarity and relatively small size, pannes demonstrate comparatively high floristic quality and diversity. Many of the plant species found within the panne community are found nowhere else in Indiana (Wilhelm 1990), and are considered relicts of the Atlantic coastal plain (Swink and Wilhelm 1994). Many of the species found in the pannes are of conservation concern because of this distribution. In addition to smooth sawgrass, pannes' characteristic plant species in the project area include golden sedge (*Carex aurea*), elk sedge (*C. garberi*), green sedge (*C. viridula*), shrubby cinquefoil

WEST BEACH PANNE

(*Dasiphora floribunda*), fringed gentian (*Gentianopsis crinita*), Kalm's St. Johnswort (*Hypericum kalmianum*), Baltic rush (*Juncus balticus* var. *littoralis*), yellow wide-lip orchid (*Liparis loeselii*), brook lobelia (*Lobelia kalmii*), horned beakrush (*Rhynchospora capillacea*), rosepink (*Sabatia angularis*), low nutrush (*Scleria verticillata*), prairie goldenrod (*Solidago ptarmicoides*), seaside arrowgrass (*Triglochin maritumum*), and horned bladderwort (*Utricularia cornuta*) (Homoya 1985; Swink and Wilhelm 1994; Wilhelm 1990). Some pannes, such as those within reach 4, are characteristically surrounded by jack pine. The deeper water zones within pannes are often dominated by algae species in the genus *Chara*.

SOUNDSCAPE

The soundscape of the shoreline and dunes area of the park includes both human and natural components. The latter consists of the sounds of the wind, sediment blowing against vegetation and waves, and sounds created by birds, insects, and other animals. The human component is generated by voices, pets, vehicles, boats, airplanes, recreational vehicles, and those sounds associated with activities at the park visitor's facility, nearby residential areas, and industrial operations. Transportation corridors, including the interstate highways near Indiana Dunes National Lakeshore and the Northern Indiana Commuter Transportation District (the South Shore Railroad), present soundscape intrusions from vehicle and track sounds and train whistles.

The park is bordered on the east and west by Michigan City and Gary, respectively, and it surrounds the industrial operations of the Port of Indiana and NIPSCO (which emit a rhythmic mechanical, industrial sound). In addition, there are three communities within the boundaries of the park: Town of Ogden Dunes, Town of Dune Acres, and Beverly Shores. At Beverly Shores, Lakefront Drive runs parallel to the beach and carries both park and local residential traffic.

Private cars, light trucks, and motorcycles, the type of vehicles that are most likely to use Lakefront Drive and other park-area beach and dune roads, emit noise levels ranging from 65 to 75 A-weighted decibels (dB[A]) at 7.5 meters. Similarly, noise levels for recreational boats with underwater exhausts typically range from approximately 75 to 85 dBA measured at a 50-foot bypass. However, depending on engine size and design (above or below water exhaust), recreational boat sound can be much higher. 2011 was the third consecutive year for the Super Boat Grand Prix sponsored by Michigan City, which is a high-speed offshore boat race. A high speed boat can produce sounds up to 170 dBA.

The sound environment of the park and project area changes seasonally. The project area experiences heaviest use in the summer season with commensurate levels of human and animal sound. While there may be more forceful wave and wind-related sound in the winter and fewer animal sounds, there are also fewer visitors to generate and experience sounds.

People perceive sound subjectively and may seek areas within the park and along the shoreline where they can experience the "natural quiet" (i.e., areas with little anthropogenic influence). Other people may prefer to enjoy the park near the more congested visitor's facilities, where human-generated sounds dominate.

In the project area, human-generated sounds dominate areas around: Mount Baldy and Central Avenue access point in reach 1; Lake View, Dunbar access point, Kemil Road access point, Porter access road, and State Park pavilion in reach 2; Portage Lakefront and Riverwalk in reach 3; and West Beach and Marquette Park in reach 4. In these areas, due to the high concentration of visitors, human-generated sounds dominate with human and vehicle sounds intruding into the natural soundscape. Figure 3-2: Visitor Access Points and Areas of Concentrated Use depicts areas within the project area with average high concentrations of park visitors. Other areas of the lakeshore provide natural quiet. Natural quiet can be experienced within areas of reaches 2, 3, and 4, where there are low concentrations of visitors.

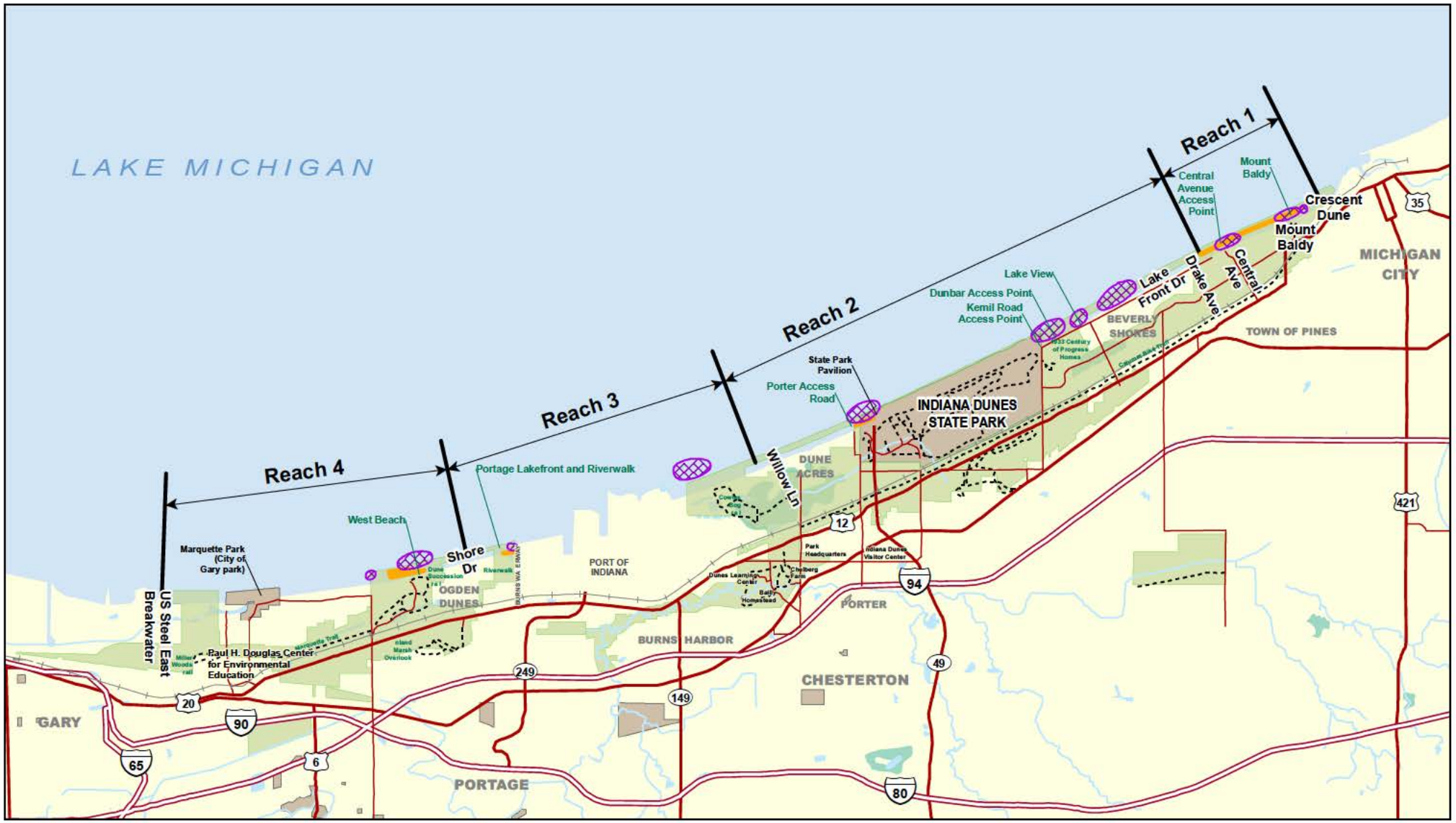
VISITOR EXPERIENCE

About two million people visit Indiana Dunes National Lakeshore each year, making it the most-visited outdoor recreation area in the region.

Visitor opportunities at Indiana Dunes National Lakeshore include hiking the dune trails; enjoying scenic views along the Lake Michigan shoreline, including the view across Lake Michigan of the Chicago skyline; enjoying the Lake Michigan beach and water access; swimming; using nonmotorized water craft; experiencing quiet, solitude, and naturalness; learning about the natural and cultural heritage of the area (e.g., glacial phenomena, diverse habitats, and human history); and understanding the complex natural history of the ecosystems that have evolved along the southern Lake Michigan shoreline.

Visitors tend to congregate at access points in the park that are interspersed along the lakefront. These include Mount Baldy, Central Avenue access point, Lake View picnic area, Dunbar access point, Kemil and Porter access points, and West Beach. See Figure 3-2: Visitor Access Points and Areas of Concentrated Use for locations of these areas. Access points and other areas of the park that experience a high concentration of visitors have more apparent and extensive anthropogenic influences, like vegetation trampling and introductions of nonnative and invasive weeds. Such influences have to be monitored and managed by the park to prevent destruction and degradation of natural resources.

In addition, there are a number of interpretive learning centers throughout the park, though not within the project area. Park staff participate in ongoing planning activities to improve visitor's experience while balancing the potential impacts to the natural environment.



Legend

- Access Points with a High Concentration of Visitors
- Visitor Impact Area

N

6,000 0 6,000 Feet

1 inch = 12,000 feet

FIGURE 3-2
VISITOR ACCESS POINTS AND AREAS OF CONCENTRATED USE

Indiana Dunes National Lakeshore
Shoreline Restoration and Management
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PARK OPERATIONS

Management of the park is organized from the superintendent's office into five functional divisions, including Interpretation and Education, Resource and Visitor Protection, Facility Management, Resource Management, and Administration (Business Services). The superintendent is responsible for overall park management. In addition to responsibilities for overall leadership and coordination of the park, staff are responsible for public and external affairs, planning and compliance, and safety, all of which relate to the actions proposed under all the action alternatives in this plan / final EIS. Shoreline erosion and associated restoration efforts result in greater personnel demands for resource protection.

The Interpretation and Education Division includes education services for diverse audiences. This division is responsible for visitor education and outreach in the park, and providing opportunities for visitors to connect with park resources and to learn how to protect park resources. Interpretive rangers provide educational information to the public and become more actively involved with the public depending on the level of public interest. Due to the duration of beach closings that would be associated with each of the action alternatives presented in this plan / final EIS, public interest is anticipated to be high and would require additional park staff and budget to provide the public with ongoing updates and interpretive programs during the life of this plan.

The Resource and Visitor Protection Division of the park is responsible for visitor and employee safety and resource protection, as well as visitor education. This division oversees beach closings during nourishment activities to ensure both visitor and employee safety. Division staff would have increased responsibilities related to safety and resource protection during the additional beach nourishment activities proposed under this plan, placing additional burdens on the park's operating budget.

The Facility Management Division maintains the park, performing routine upkeep of facilities, structures, and landscapes, including the park's shoreline and forested dunes. Ongoing erosion and degradation of the shoreline and dunes taxes park staff and budgets with added responsibilities related to resource protection and restoration activities.

The Resources Management Division of the park is responsible for natural resource inventory and monitoring, managing natural resources research, protecting threatened and endangered species and species of concern, restoring disturbed sites, managing invasive nonnative species, and protecting and preserving cultural resources including historic structures, cultural landscapes, archeological resources, ethnographic resources, and museum objects. Park resources are actively monitored and managed during beach nourishment activities and would continue to be with any of the additional nourishment activities proposed under any of the action alternatives presented in this plan / final EIS. Increasing the duration or frequency of such activities through the beach nourishment activities proposed under this plan would incrementally add to park staff workloads and place additional drains on park budgets.

CHAPTER 4

Environmental Consequences

INTRODUCTION

This "Environmental Consequences" chapter analyzes both beneficial and adverse impacts that would result from implementing any of the alternatives considered in this *Shoreline Restoration and Management Plan / Final Environmental Impact Statement* (EIS). The "Environmental Consequences" chapter also includes the methodology and definitions of impact thresholds (e.g., negligible, minor, moderate, and major), methods used to analyze impacts, the analysis used for determining cumulative effects, and a cumulative impacts scenario. A summary of the environmental consequences for each alternative is provided in tables 2-3 and 2-4, which can be found in "The Alternatives" chapter. The resource topics presented in the "Environmental Consequences" chapter, and the organization of the topics, correspond to the resource discussions contained in the "Affected Environment" chapter.

GENERAL METHODOLOGY FOR ESTABLISHING IMPACT THRESHOLDS AND MEASURING EFFECTS BY RESOURCE

The following elements were used in the general approach for establishing impact thresholds and measuring the effects of the alternatives on each resource category:

- general analysis methods as described in the guiding regulations
- basic assumptions used to formulate the specific approaches used in this analysis
- thresholds used to define the intensity of impact resulting from each alternative
- methods used to evaluate the cumulative effects of each alternative in combination with unrelated factors or actions affecting park resources

These elements are described in the following sections.

General Analysis Methods

The analysis of impacts follows CEQ guidelines and Director's Order 12: *Conservation Planning, Environmental Impact Analysis, and Decision-making* procedures (NPS 2001) and is based on the underlying goals of restoring natural shoreline processes, preserving the shoreline ecosystem, and providing opportunities for quality visitor experiences consistent with the purpose and significance of the park. This analysis incorporates the best available scientific literature applicable to the region and setting and the actions being considered in the alternatives.

The National Park Service has created an interdisciplinary team to provide important input to the impact analysis. For each resource topic addressed in the "Environmental Consequences" chapter, the applicable analysis methods are discussed.

Assumptions

Several guiding assumptions were made to provide context for this analysis. These assumptions are described below.

Analysis Period. For goals, objectives, and specific implementation actions needed to restore and manage the shoreline at Indiana Dunes National Lakeshore, a 20-year lifespan of each alternative was assumed. Thus, the analysis period used for assessing impacts in this plan / final EIS is 20 years.

The National Park Service assumes that beach nourishment via any of the alternatives would require time to monitor and oversee the actions associated with each of the alternatives for the duration of the plan (i.e., 20 years).

Duration and Type of Impacts

The following assumptions were used for all impact topics (the terms "impact" and "effect" are used interchangeably throughout this document):

- Short-term impacts are impacts that would be temporary, lasting for one year or less following an action.
- Long-term impacts are impacts that would last longer than one year and that would be permanent.
- Direct impacts are impacts that would be directly caused by a shoreline management action which would occur when and where the action was implemented.
- Indirect impacts are impacts that would occur from shoreline management actions that would occur later in time or farther in distance than when and where the action was implemented.

Geographic Area Evaluated for Impacts.

The geographic project area for this plan includes beach reaches 1 through 4 in Indiana Dunes National Lakeshore, as described in "The Alternatives" chapter.

For the alternatives assessed, it is assumed that providing several thousands of cubic yards of nourishment material to reach 1 would affect not only reach 1, but reach 2 and a portion of reach 3, as well. Likewise, providing several thousands of cubic yards of nourishment material to reach 3 would indirectly affect downdrift shorelines within reach 4. The additional nourishment material in reach 3 would be transported downdrift by natural processes (i.e., wave action and storm events).

Future Trends. Visitor use and demand are anticipated to follow trends similar to recent years. The number of yearly visitors to Indiana Dunes National Lakeshore is about two million. In the absence of notable anticipated changes in visitation and park staffing, the impact analysis assumes these levels would remain similar to present levels.

IMPACT THRESHOLDS

Determining impact thresholds is a key component in applying NPS *Management Policies 2006* and Director's Order 12. These thresholds provide the reader with an idea of the intensity of a given impact within a specific topic. The impact threshold is determined primarily by comparing the effect to a relevant standard based on regulations, scientific literature and research, or best professional judgment. Intensity definitions are provided separately for each impact topic analyzed in this document because definitions of intensity vary by impact topic. Intensity definitions are provided throughout the analysis for negligible, minor, moderate, and major impacts.

CUMULATIVE EFFECTS ANALYSIS METHOD

The CEQ regulations for implementing the National Environmental Policy Act of 1969, as amended (NEPA) require an assessment of cumulative effects in the decision-making process for federal projects. Cumulative impacts are defined as "the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions" (40 Code of Federal Regulations [CFR] 1508.7). These actions were identified, and cumulative impacts were determined, by combining the impacts of alternatives with those of the other past, present, and reasonably foreseeable future actions. Therefore, it was necessary to identify other ongoing or reasonably foreseeable future projects at Indiana Dunes National Lakeshore and, if applicable, the surrounding region. The geographic scope for this analysis includes elements mostly within the shoreline of southern Lake Michigan, while the temporal

scope includes projects within a range of approximately 20 years. Given this, the following projects were identified for the purpose of conducting the cumulative effects analysis.

CUMULATIVE IMPACT SCENARIO

Past Actions Within and Around Indiana Dunes National Lakeshore

- Three man-made structures that constitute barriers to littoral drift and affect the park were constructed in and around the project area. These structures are federal and industrial harbors that impact the natural sediment transport by disrupting water flow and producing accretion to the east (updrift) and erosion to the west (downdrift). These include the east adjacent Michigan City Harbor (initial construction in 1834, harbor completed in the early 1900s), the Port of Indiana industrial complex (constructed in the late 1960s), and the west adjacent Gary-U.S. Steel breakwater (constructed in the early 1900s).
- A permanent electric barrier was constructed by the U.S. COE in the Chicago Sanitary and Ship Canal to deter movement by invasive nonnative fish species across this artificial connection between the Mississippi River and Great Lakes drainages.
- The park designated the appropriate route to and from Mount Baldy from the parking lot in an effort to reduce social trails in reach 1 of the beach.
- The initial Marquette Plan: The Lakeshore Reinvestment Strategy (IDNR *et al.* 2005) was completed in 2005 and addressed public access and redevelopment of Indiana Dunes National Lakeshore from the Illinois state line to the Port of Indiana, with funding by the cities of Whiting, East Chicago, Hammond, Gary, and Portage. Portage Lakefront and Riverwalk are results of this plan.
- Industrial complexes in the area, like the Northern Indiana Public Service Company (NIPSCO), were constructed and became operational.
- Transportation corridors were constructed within and around the park.

Present Actions Within and Around Indiana Dunes National Lakeshore

- Clean sediment nourishment is accepted from upland sources on an intermittent basis in reach 1.
- The park is restoring the foredune and dune complex by stabilizing select areas of eroded dunes with native vegetation, fencing off highly eroded and environmentally sensitive areas, and providing expanded visitor outreach and education opportunities about these actions.
- The park installs fencing to protect the leeward slope of Mount Baldy to limit anthropogenic influences in reach 1.
- The park manages invasive vegetation, currently targeting sand ryegrass (*Leymus arenarius*) and spotted knapweed (*Centaurea maculosa*) in the foredune complex; purple loosestrife (*Lythrum salicaria*), common reed (*Phragmites australis*), and hybrid cattail (*Typha* x *glauca*) in the panne; and some woody invasive vegetation, such as Siberian elm (*Ulmus pumila*), black locust (*Robinia pseudoacacia*), and tree-of-heaven (*Ailanthus altissima*), throughout these complexes in reaches 1 and 2.
- Clean sediment nourishment is accepted from lake dredging projects on an intermittent basis in reach 3.
- At blowout locations, including Portage Lakefront and Riverwalk, some invasive plant management is performed to help protect Pitcher's thistle (*Cirsium pitcheri*) populations in reaches 3 and 4; the U.S. Geological Survey monitors these populations.

- Nonnative invasive plant species are being managed in the panne in reaches 3 and 4. These efforts target spotted knapweed, yellow sweet clover (*Melilotus officinalis*), and prairie sunflower (*Helianthus petiolaris*) at Portage Lakefront and Riverwalk; purple loosestrife and common reed in the panne; and sand ryegrass in the foredune complex. In addition, some management of oriental bittersweet (*Celastrus orbiculatus*) (that is encroaching on the dune complex) is performed.
- The park is currently preserving the pannes at West Beach and Miller by managing invasive nonnative plant species, targeting purple loosestrife, common reed, and hybrid cattail in reach 4.
- Ongoing planned facility upgrades are performed in the park.
- To limit anthropogenic influences in the park, the staff provides education and outreach to visitors.
- Current resource protection and restoration projects in the park include an early detection and rapid response program and an Invasive Plant Management Plan.
- The park maps and monitors treated nonnative invasive plant species in Indiana Dunes National Lakeshore.
- The park provides education and outreach about the impacts of invasive nonnative plant species.
- The Northern Indiana Commuter Transportation District (the South Shore Railroad) traverses the park.
- The Super Boat Grand Prix, a high-speed offshore boat race sponsored by Michigan City, is held annually near the park.
- The Calumet Harbor and River project involves dredging various segments of the Calumet River to maintain channel depth (allowing continued commodity exchange and transport). The Calumet Harbor, which is the second largest port on the Great Lakes, is the primary link between the Inland-Waterway system, foreign ports, and the Great Lakes (and is one of only two possible routes between these) (COE 2011c).
- Ships' ballast water has accounted for 55% to 70% of reported aquatic invasive species introductions in to the Great Lakes since 1959, when the St. Lawrence Seaway opened and provided a route in to the Great Lakes for trade (National Academy of Sciences 2008).

Reasonably Foreseeable Future Actions Within and Around Indiana Dunes National Lakeshore

- The park proposes to develop a picnic area near the Porter access point.
- NIPSCO is going to realign the outflow at the Bailly Generating Station.
- The town of Michigan City proposes to build a parking lot east of Mount Baldy for access to Crescent Dune.
- Phase II of the Marquette Plan (IDNR *et al.* 2005), which focuses on Indiana Dunes National Lakeshore from the Port of Indiana to the Michigan-Indiana state line, is being funded through a grant from the Indiana Department of Natural Resources (IDNR) Lake Michigan Coastal Program with matching funds from the Gaylord and Dorothy Donnelley Foundation, the cities of La Porte and Michigan City, and La Porte County. This plan focuses on identifying the needs of the smaller communities and creating a vision that would identify and protect greenways, identify possible trails in the region, and address the needs of smaller communities.
- The park is considering realigning some trails, as well as developing a mitigation plan for new/proposed access points and trails to Crescent Dune to limit anthropogenic influences.
- The park plans to enforce visitor use of approved trails in the park in all reaches to limit anthropogenic influences.
- To help limit social trails in reach 1, the park plans to designate an appropriate route to the beach from the Kemil Road parking lot, and to the foredune complex, including blowouts, from the Kemil Road access point.

- The park proposes to restore the foredune and dune complex by stabilizing eroded dunes with native vegetation, and fencing off highly eroded and environmentally sensitive areas on the foredune to allow for ecological recovery of natural communities.
- The park proposes to expand current public education and outreach efforts.
- Outside of the proposed project area, no additional modifications to the shoreline are likely, as the harbors and breakwaters associated with the adjacent federal and industrial harbors have already been constructed. It cannot be predicted whether owners of adjacent properties would continue to armor or otherwise modify their respective beachfronts. In the event that additional shoreline structures are constructed, the littoral drift along Lake Michigan's shoreline would continue to be disrupted and result in additional challenges to the natural and human environment at Indiana Dunes National Lakeshore.
- Future introductions of aquatic invasive species from ships' ballast water may be effectively managed through ballast water management techniques, such as ballast water exchange, saltwater flushing, or shipboard treatment, and through restricting access to the Great Lakes to vessels that have taken protective measures like these to ensure they do not harbor aquatic invasive species.

COASTAL PROCESSES

METHODOLOGY

Resource specialists conducted site visits to the park to observe existing conditions and assess the potential effectiveness of the alternatives in addressing the issues involved in the restoration of natural coastal processes. Various technical documents were reviewed to understand the history of beach nourishment activities and the factors involved in coastal processes, sediment transport, and dune formation. Alternatives were evaluated based on the potential to respond to the desired future conditions, including the effectiveness of the alternative in balancing the quantities of sediment throughout the project area, fulfilling the estimated sediment budget deficit, preventing continued erosion in critical areas of the shoreline, and providing for the natural processes of dune formation.

Impact Intensity Level Definitions

Intensity level thresholds for coastal processes are defined as follows:

Negligible: The impact is barely detectable, and would result in no noticeable or perceptible changes to the sediment transport and/or dune formation processes.

Minor: The impact is slight but detectable, and would result in small but noticeable changes to the sediment transport and/or dune formation processes.

Moderate: The impact is readily apparent, and would result in easily detectable changes to the sediment transport and/or dune formation processes.

Major: The impact is severely adverse, or exceptionally beneficial, and would result in appreciable changes to the sediment transport and/or dune formation processes.

SHORELINE AND BEACH COMPLEX, REACHES 1 AND 2

Alternative A (No-action Alternative)

Sediment Transport Processes. The dunes, the swash zone, and the nearshore area are dynamic high-energy areas, subject to the forces of wind and waves. Sediment is moved offshore in the winter and returns onshore in the spring and summer. Sediment placed on the shoreline during beach nourishment activities is re-distributed between the zones in a more stable profile. Despite current nourishment efforts to stabilize the shore, erosion of the shoreline would continue as the quantity of material currently being placed is less than the estimated sediment budget deficit. The accretion area at Michigan City would continue to grow because sediment is being transported to the shoreline from upland sources, as sediment supply meant to drift naturally along the shoreline is blocked by the existing navigational structure (i.e., Michigan City Harbor).

Although the existing program of beach nourishment has had a positive effect in reducing the annual sediment budget deficit, the amount of sediment being placed along the shoreline is substantially less than the estimated loss, leaving the sediment budget deficit. Therefore, selection of the no-action alternative would result in a moderate, long-term, adverse impact, due to the continued sediment budget deficit and shoreline erosion.

Dune Formation Processes. The current nourishment program includes placing material primarily on the beach at Crescent Dune, and using heavy equipment to grade the material into a more natural topography. Shoreline sediment is transported by natural processes (i.e., wave action, wind) to the foredune area where it provides material for dune formation. The amount of material placed during current beach nourishment

activities is less than the annual sediment loss, resulting in continued erosion. The existing nourishment program has helped reduce impacts on dune formation; however, due to the sediment budget deficit, dune erosion would continue under the no-action alternative. Therefore, the no-action alternative would result in moderate, long-term, adverse impacts on dune formation processes.

Cumulative Impacts. The "Cumulative Impact Scenario" section of the "Environmental Consequences" chapter describes the past, present, and reasonably foreseeable future actions in or surrounding the project area. Many of these actions have affected coastal processes, including the construction of man-made structures, which have impacted the natural littoral drift along the lakeshore. The main structure affecting reaches 1 and 2 is the Michigan City Harbor. Construction of the harbor resulted in areas of accretion (east of the harbor) and areas of erosion (west of the harbor). Additionally, the Calumet Harbor and River project and its associated dredging activities affect littoral drift in the Great Lakes resulting in sediment accretion and sediment budget deficits along shorelines in the project area. Present beach nourishment activities have provided some sediment in the areas of erosion, but volumes are inadequate to account for the annual sediment budget deficit, and do not address issues of sediment accretion. No future modifications to the shoreline have been identified within reaches 1 and 2, as surrounding and adjacent federal and industrial harbors and other man-made shoreline structures have already been constructed. Cumulative impacts on coastal processes under alternative A would be moderate, long-term and adverse.

Conclusion. Despite the continuation of the current nourishment program by the COE, under the no-action alternative, sediment budget deficit and erosion would continue to affect Indiana Dunes National Lakeshore's sandscapes and shorelines, resulting in an overall moderate, long-term, adverse impact. As erosion continued, the integrity of cultural and natural resources along the shoreline, as well as nearby infrastructure would be threatened. Additionally, existing navigational and industrial structures along the lakeshore would continue to disrupt sediment transport. Cumulative impacts on coastal processes under alternative A would be moderate, long-term and adverse. Actions under alternative A would provide no incremental increase to the overall cumulative impacts.

Alternative B-1 (Beach Nourishment via Upland Sources, Annual Frequency)

Sediment Transport Processes. Under alternative B-1, sediment would be mined and placed on the beach each year from a permitted upland source. Placing additional sediment on the beach in reach 1 would initially increase beach size within the placement area in front of Crescent Dune and Mount Baldy. The additional nourishment material would be sufficient to maintain the current shoreline position for approximately one year, as natural wave action would continue to erode the sediment after placement. The shorelines downdrift of Crescent Dune and Mount Baldy would receive a large infusion of sediment following the material placement, affecting not only reach 1, but reach 2 and a portion of reach 3, as well. The accretion area at Michigan City would continue to grow because sediment would be transported to the beach from an upland source and sand supply meant to drift naturally along the shoreline would be blocked by the existing navigational structure.

Implementing alternative B-1 would result in moderate, long-term, beneficial impacts as the estimated sediment budget deficit quantity would be provided.

Dune Formation Processes. Under alternative B-1, sediment would be mined and placed on the beach each year from a permitted upland source. The placed sediment would erode over the course of

approximately one year. Placement of the sediment would provide additional material available on land for aeolian (wind) transport, thus encouraging foredune development. Beach placement also would provide some buffering against storm events. The additional sediment on the beach would protect the current shoreline profile from increased erosion resulting from intense wave action, particularly during storm events.

The actions associated with alternative B-1 would result in moderate, long-term, beneficial impacts as the sediment placed on the beach, in conjunction with wind action, would allow for additional sediment supply to create foredunes.

Cumulative Impacts. Cumulative impacts would generally be similar to those described for alternative A, with the exception that beach nourishment activities would include the amount of sediment needed to balance the annual sediment budget deficit. Cumulative impacts on coastal processes would be negligible to minor, long-term and adverse. The existing man-made structures would persist and continue to create areas of accretion and sediment budget deficit, which would require continued beach nourishment activities to mitigate.

Conclusion. Placing the proposed quantity of sediment on the beach in reach 1 would account for the estimated sediment budget deficit, and thereby maintain the current shoreline profile. Actions under alternative B-1 would also provide additional sediment to encourage foredune development along the shoreline, resulting in moderate, long-term, beneficial impacts on coastal processes. Cumulative impacts on coastal process would be negligible to minor, long-term and adverse.

Actions under alternative B-1 would provide incremental beneficial increases to the overall adverse cumulative impacts described under alternative A. Despite these actions, existing navigational and industrial structures along the lakeshore would continue to disrupt the natural littoral drift along the lakeshore.

Alternative B-5 (Beach Nourishment via Upland Sources, Five-Year Frequency)

Sediment Transport Processes. Under alternative B-5, a five-year quantity of sediment would be mined and placed on the beach every five years, initially increasing beach size along the length of reach 1. The additional nourishment material would be sufficient to maintain the current shoreline position for approximately five years, as natural wave action would continue to erode the sediment after placement. The shorelines downdrift of reach 1 would receive a large infusion of sediment following the material placement, affecting not only reach 1, but reach 2 and a portion of reach 3, as well. The accretion area at Michigan City, and the beach at Washington Park, would continue to grow because sediment would be transported from upland sources and sediment supply meant to drift naturally along the shoreline would be blocked by the existing navigational structure.

The actions associated with alternative B-5 would result in moderate, long-term, beneficial impacts, as the estimated sediment budget deficit quantity would be provided.

Dune Formation Processes. A five-year quantity of mined sediment on the beach in reach 1 would erode over the course of approximately five years. Placement of the sediment would provide additional material available on land for aeolian (wind) transport, thus encouraging foredune development. Placing a five-year quantity of sediment on the beach would result in additional protection against storm events. The additional sediment would help protect the current shoreline profile against increased erosion from intense wave action, particularly during storm events. The actions associated with alternative B-5 would result in moderate to major, long-term, beneficial impacts as the additional material

on the beach, in conjunction with wind action, would encourage foredune development. The additional material would also provide more buffering against intense storm events than the smaller amount of sediment provided for under an annual program of beach nourishment.

Cumulative Impacts. Cumulative impacts would generally be as described for alternative A, with the exception that beach nourishment activities would include the amount of sediment needed to balance the annual sediment budget deficit. Cumulative impacts on coastal processes would be negligible, long-term and adverse. The impacts of the existing man-made structures would persist, continuing to create areas of accretion and erosion, which would require the continued beach nourishment activities to mitigate.

Conclusion. Placing the proposed quantity of sediment on the beach in reach 1 every five years would account for the estimated sediment budget deficit, and thereby maintain the current shoreline profile. The actions associated with alternative B-5 would also provide a large quantity of sediment on the beach to facilitate foredune development along the shoreline, resulting in major, long-term, beneficial impacts on coastal processes. Cumulative impacts on coastal process would be negligible, long-term and adverse.

Actions under alternative B-5 would provide incremental beneficial increases to the overall adverse cumulative impacts described under alternative A. Despite these actions, existing navigational and industrial structures along the lakeshore would continue to disrupt the natural littoral drift along the lakeshore.

Alternative C-1 (Beach Nourishment via Dredged Sources, Annual Frequency)

Sediment Transport Processes. Under alternative C-1, sediment would be dredged from an updrift location and be placed along the beach in reach 1. As under alternative B-1, placing additional sediment on the beach in reach 1 would result in an initial increase in beach size within the placement area at Crescent Dune. The additional nourishment material would be sufficient to maintain the current shoreline position for approximately one year, as natural wave action would continue to erode the sediment after placement. The shorelines downdrift of Crescent Dune and Mount Baldy would receive a large infusion of sediment, originating from Lake Michigan, following the material placement, affecting not only reach 1, but reach 2 and a portion of reach 3, as well.

Transporting sediment from an updrift to a downdrift location would mimic natural processes as the material used would remain within the Lake Michigan system. Implementing alternative C-1 therefore would result in moderate to major, long-term, beneficial impacts as the estimated sediment budget deficit would be provided from an updrift source, more closely mimicking natural processes.

Dune Formation Processes. Under alternative C-1, additional sediment would be dredged from an updrift location and placed at Crescent Dune. This sediment would erode over the course of approximately one year. Placement of the sediment would provide additional material available on land for aeolian (wind) transport, thus encouraging foredune development. Beach placement would provide some buffering against storm events. The additional sediment on the beach would protect the current shoreline profile from increased erosion resulting from intense wave action, particularly during storm events.

Implementing alternative C-1 would result in moderate, long-term, beneficial impacts as the sediment placed on the beach, in conjunction with wind action, would allow for additional sediment supply to create foredunes.

Cumulative Impacts. Cumulative impacts under alternative C-1 would generally be as described for alternative A, with the exception that beach nourishment activities would

include the amount of sediment needed to balance the annual sediment budget deficit. Additionally, sediment would be taken from an updrift location that would more closely mimic the natural coastal processes as the material used would remain within the Lake Michigan system. Cumulative impacts on coastal processes would be negligible to minor, long-term and adverse.

Conclusion. Placing the proposed quantity of sediment on the beach in reach 1 would account for the calculated sediment budget deficit, and thereby maintain the current shoreline profile. Additionally, dredging sediment from an updrift location would more closely mimic natural processes, as compared to using material from upland sources. Implementing alternative C-1 would also provide additional sediment to encourage foredune development along the shoreline, resulting in moderate to major, long-term, beneficial impacts on coastal processes. Cumulative impacts on coastal process would be negligible to minor, long-term and adverse.

Actions under alternative C-1 would provide incremental beneficial increases to the overall adverse cumulative impacts described under alternative A. Despite these actions, existing navigational and industrial structures along the lakeshore would continue to disrupt the natural littoral drift along the lakeshore.

Alternative C-5 (Beach Nourishment via Dredged Sources, Five-Year Frequency)

Sediment Transport Processes. As described under alternative C-1, sediment would be dredged from an updrift location and would be placed along the beach in reach 1; however, under alternative C-5, a five-year quantity would be used to nourish the beach. Placing a five-year quantity of sediment in reach 1 would initially increase beach size along the length of reach 1. The additional nourishment material would be sufficient to maintain the current shoreline position for approximately five years, as natural wave action would continue to erode the sediment after placement. The shorelines downdrift of reach 1 would receive a large infusion of sediment, originating from Lake Michigan, following the material placement, affecting not only reach 1, but reach 2 and a portion of reach 3, as well.

Transporting sediment from an updrift to a downdrift location would mimic natural processes, as material used would remain within the Lake Michigan system. Implementing alternative C-5 therefore, would result in moderate to major, long-term, beneficial impacts as the estimated sediment budget deficit would be provided from an updrift source, more closely mimicking natural processes.

Dune Formation Processes. Under alternative C-5 a five-year quantity of sediment would be dredged from an updrift location and placed at Crescent Dune, providing additional sediment along the majority of reach 1. This sediment would erode over the course of approximately five years. Placement of the sediment would provide additional material available on land for aeolian (wind) transport, thus encouraging foredune development. Placing a five-year quantity of sediment on the beach would provide additional protection against storm events. The additional sediment on the beach would protect the current shoreline profile from increased erosion resulting from intense wave action, particularly during storm events. Implementing alternative C-5 would result in moderate to major, long-term, beneficial impacts as the additional quantity of material on the beach, in conjunction with wind action, would encourage foredune development. The additional quantity of material would also provide buffering against intense storm events.

Cumulative Impacts. Cumulative impacts under alternative C-5 would generally be as described for alternative A, with the exception that beach nourishment activities would include the amount of sediment needed to

balance the annual sediment budget deficit. Additionally, there would be a reduction in areas of accretion, which would be used as sources of sediment for beach nourishment operations. Cumulative impacts on coastal processes would be negligible, long-term and adverse.

Conclusion. Placing the proposed quantity of sediment on the beach in reach 1 every five years would account for the estimated sediment budget deficit, and thereby maintain the current shoreline profile. Implementing alternative C-5 would also provide a large quantity of sediment on the beach from an updrift source to facilitate foredune development along the shoreline, resulting in moderate to major, long-term, beneficial impacts on coastal processes. Cumulative impacts on coastal process would be negligible, long-term and adverse.

Actions under alternative C-5 would provide incremental beneficial increases to the overall adverse cumulative impacts described under alternative A. Despite these actions, existing navigational and industrial structures along the lakeshore would continue to disrupt the natural littoral drift along the lakeshore.

Alternative D (Beach Nourishment via Permanent Bypass System)

Sediment Transport Processes. Under alternative D, sediment would be placed along the beach in reach 1 from updrift of the Michigan City Harbor, and transported to the shoreline via a permanent bypass system. As with the previously described alternatives, placing additional sediment on the beach in reach 1 would result in an initial increase in beach size within the placement area at Crescent Dune. The additional nourishment material would be sufficient to maintain the current shoreline position for approximately one year, as natural wave action would continue to erode the sediment after placement. The shorelines downdrift of Crescent Dune and Mount Baldy would receive an infusion of sediment following the material placement, affecting not only reach 1, but reach 2 and a portion of reach 3, as well.

Transporting sediment from an updrift to a downdrift location in this manner would mimic the natural processes, as material used in beach nourishment would remain within the Lake Michigan system. Implementing alternative D therefore, would result in moderate to major, long-term, beneficial impacts as the estimated sediment budget deficit would be provided from a source updrift, more closely mimicking natural processes.

Dune Formation Processes. Under alternative D, sediment would be transported to the shoreline in reach 1 via a permanent bypass system from updrift of the Michigan City Harbor. Under alternative D, placed material would erode over the course of approximately one year. Placement of the sediment would provide additional material available on land for aeolian (wind) transport, thus encouraging foredune development. Beach placement also would provide some buffering against storm events. The additional sediment on the beach would protect the current shoreline profile from increased erosion resulting from intense wave action, particularly during storm events.

Implementing alternative D would be moderate, long-term, beneficial impacts as the sediment placed on the beach, in conjunction with wind action, would provide additional sediment supply to create foredunes.

Cumulative Impacts. Cumulative impacts under alternative D would generally be as described for alternative A, with the exception that beach nourishment activities would include the amount of sediment needed to balance the annual sediment budget deficit. Additionally, there would be a reduction in areas of accretion which would be used as sources of sediment for beach nourishment operations. Cumulative impacts would be negligible to minor, long-term and adverse.

Conclusion. Placing the proposed quantity of sediment on the beach in reach 1 would account for the estimated sediment budget deficit, and thereby maintain the current shoreline profile. Additionally, dredging sediment from an updrift location would more closely mimic natural processes, as compared to using material from upland sources. Implementing alternative D would also provide additional sediment to encourage foredune development along the shoreline, resulting in moderate to major, long-term, beneficial impacts on coastal processes. Cumulative impacts on coastal process would be negligible to minor, long-term and adverse.

Actions under alternative D would provide incremental beneficial increases to the overall adverse cumulative impacts described under alternative A. Despite these actions, existing navigational and industrial structures along the lakeshore would continue to disrupt the natural littoral drift along the lakeshore.

Alternative E (Submerged Cobble Berm and Beach Nourishment, Annual Frequency)

Sediment Transport Processes. Under alternative E, a submerged cobble berm along the shoreline of reach 1 would be constructed. The submerged cobble berm would be comprised of appropriate-sized aggregate material from local glacial deposits which would be re-distributed across the lake bottom by natural wave action. The distribution would move the smaller aggregate closer to the shoreline, while the larger material would generally stay within a few feet of the submerged cobble berm. Distribution would be variable, depending on the intensity of storm events. Prior to breakdown of the submerged cobble berm, wave energy within the nearshore would be dissipated, thus increasing the likelihood of sediment retention in the nearshore. After the submerged cobble berm has been spread along the lake substrate, lakebed down-cutting would decrease as the aggregate material would create a protective layer.

The submerged cobble berm would be used in conjunction with a beach nourishment program to restore reach 1. The potential exists for reduced nourishment quantities, as the submerged cobble berm would increase sediment retention. The placement of nourishment material would be conducted to mitigate erosion within reach 1, and to maintain the current shoreline profile.

A moderate, long-term, beneficial impact on sediment transport processes would result from implementing alternative E. Annual nourishment from a dredged source would be determined in coordination with IDNR and would more closely mimic natural processes. Material used for the submerged cobble berm would provide additional protection of the clay sill on the lake bottom and would be similar to material historically found in reach 1. The submerged cobble berm, and the eventual distribution of its aggregate material, would help protect the shoreline from erosion due to storm events, and maintain a more stable shoreline profile.

Dune Formation Processes. Under alternative E, the submerged cobble berm would be used in conjunction with a beach nourishment program to restore reach 1 of Indiana Dunes National Lakeshore. Placement of the sediment would provide additional material available on land for aeolian (wind) transport, thus encouraging foredune development. Beach placement also would provide some buffering against storm events. The submerged cobble berm would provide additional retention of sediment in the area of placement.

Implementing alternative E would result in moderate, long-term, beneficial impacts as the submerged cobble berm would provide longer retention of the sediment. The material placed on the beach in conjunction with the submerged cobble berm, would allow for additional sediment supply to create foredunes. Beach placement of nourishment

materials also would provide some buffering against storm events.

Cumulative Impacts. Cumulative effects under alternative E would generally be similar to those described under alternative A. The combination of the effects of the submerged cobble berm along with beach nourishment activities would create and maintain a more natural and stable shoreline. Cumulative effects under alternative E would be negligible, long-term and adverse.

Conclusion. Constructing a submerged cobble berm in addition to placing nourishment material from an updrift source would account for the estimated sediment budget deficit, and thereby maintain the current shoreline profile. Placing cobble aggregate material from local glacial deposits in reach 1 would more closely replicate material historically found in this area of the shoreline. Additionally, dredging sediment from an updrift location would more closely mimic natural processes, as compared to using material from upland sources. Implementing alternative E would increase sediment retention in the area of placement, provide additional sediment to encourage foredune development along the shoreline, and would result in moderate, long-term, beneficial impacts on coastal processes. Cumulative impacts on coastal process would be negligible, long-term and adverse.

Actions under alternative E would provide incremental beneficial increases to the overall adverse cumulative impacts described under alternative A. Despite these actions, existing navigational and industrial structures along the lakeshore would continue to disrupt the natural littoral drift along the lakeshore.

Alternative F (Beach Nourishment, Annual Frequency with a Mix of Small Natural Stone at the Shoreline) – Preferred Alternative

Sediment Transport Processes. Under alternative F, a beach nourishment program to restore reach 1 would be implemented. Under this alternative an additional volume of small native stones native to the shoreline region would be added to the dredged materials at the shoreline. These small native stones would be consistent in size and volume with those presently found downdrift in dynamically stable beach zones. The combination of dredged and trucked in materials would be used as beach nourishment material to restore reach 1 of Indiana Dunes National Lakeshore. The objectives of adding the native stone to the nourishment material would be to stabilize the shoreline downdrift of the Michigan City Harbor by providing a more erosion resistant component, and to enhance aquatic habitat by diversifying the nearshore substrate consistent with dynamically stable reaches.

A moderate, long-term, beneficial impact on sediment transport processes would result from implementing alternative F. A quantity up to 136,500 cubic yards (the identified annual budget deficit for this reach) of lake-bottom sediment would be hydraulically placed annually on the beach in reach 1 to provide nourishment and protection of the shoreline. Additional stone materials would be added to beach nourishment materials until the desired shoreline condition was reached. The mixing of native stone material with sediment would reduce shoreline erosion by providing a mix of stone, consistent with dynamically stable shoreline reaches, that is more resistant to wave energy.

Dune Formation Process. Under alternative F, small native stones native to the shoreline would be used in conjunction with a beach nourishment program to restore reach 1 of Indiana Dunes National Lakeshore. Placement of the sediment would provide additional material available on land for aeolian (wind) transport, thus encouraging

foredune development. Beach placement also would provide some buffering against storm events.

Implementing alternative F would result in moderate, long-term, beneficial impacts as the native stones would provide longer sediment retention along the beach. The material placed on the beach in conjunction with the native stones, would allow for additional sediment supply to create foredunes. Beach placement of nourishment materials also would provide some buffering against storm events.

Cumulative Impacts. Cumulative effects under alternative F would generally be similar to those described under alternative A. The combination of the effects of the beach nourishment activities with a mix of natural stone, dredged sediment, and coarse upland material at the shoreline would create and maintain a more natural and stable shoreline. Cumulative effects under alternative F would be negligible, long-term and adverse.

Conclusion. Placing nourishment material from an updrift source on an annual basis with a mix of natural stone, dredged sediment, and coarse upland material at the shoreline would account for the estimated sediment budget deficit, and thereby maintain the current shoreline position. The mixing of native stone material with sediment would reduce shoreline erosion by providing a mix of stone that is consistent with dynamically stable shoreline reaches and would be more resistant to wave energy. Additionally, dredging sediment from an updrift location would more closely mimic natural processes, as compared to using material from upland sources. Implementing alternative F would increase sediment retention in the area of placement, provide additional sediment to encourage foredune development along the shoreline, and would result in moderate, long-term, beneficial impacts on coastal processes. Cumulative impacts on coastal process would be negligible, long-term and adverse.

Actions under alternative F would provide incremental beneficial increases to the overall adverse cumulative impacts described under alternative A. Despite these actions, existing navigational and industrial structures along the lakeshore would continue to disrupt the natural littoral drift along the lakeshore.

SHORELINE AND BEACH COMPLEX, REACHES 3 AND 4

Alternative A (No-action Alternative)

Sediment Transport Processes. Under alternative A, sediment would continue to be dredged annually around the NIPSCO/Bailly intake. The dredged material would be placed in the nearshore at Portage Lakefront and Riverwalk, while sediment from Burns International Harbor would have an offshore, open-water placement. Despite intermittent nearshore placement activities associated with dredging, erosion of the shoreline would continue as the quantity of material being placed would not address the sediment budget deficit in the area. Additionally, nearshore placement would typically be less effective than beach nourishment as less sediment would be transported via wave action to the shoreline.

Although implementing the no-action alternative would propose continuing current dredging and placement of sediment in the nearshore, an annual sediment budget deficit in the erosion areas of the lakeshore would still result. The sediment being placed in the nearshore at Portage Lakefront and Riverwalk would continue to help reduce the sediment budget deficit; however, the area would still experience a net loss of sediment, impacting the natural sediment transport processes. Accordingly, impacts under the no-action alternative would be minor to moderate, long-term and adverse. As dredging of the intake area would be intermittent, the accretion areas would continue to grow, potentially achieving a stable profile and allowing sediment to bypass harbor structures. Sediment would accumulate in the navigational channel, and the sediment would

adversely affect the intake as well as a warm-water industrial discharge point.

Dune Formation Processes. Current management practices by the COE include dredging material from around the NIPSCO/Bailly intake, and placing that sediment in the nearshore at Portage Lakefront and Riverwalk. Placement of sediment in this area is less effective relative to foredune creation than if it were placed on the beach, as much of the material would be transported downdrift or further lakeward to open waters rather than towards the shoreline. Subsequently, less is available to be transported via wind action onto the beach to form embryonic dunes. If the no-action alternative were implemented, beach erosion would continue, thus threatening park infrastructure along the shoreline. Taking no new actions in the park would result in minor to moderate, long-term, adverse impacts.

Cumulative Impacts. The primary past and present actions that have affected coastal processes are the construction of man-made structures, which have impacted the natural littoral drift along the lakeshore. The main structures in reaches 3 and 4 are associated with the Port of Indiana and Gary-U.S. Steel breakwater. The presence of these structures has resulted in areas of accretion (east of the structures) and areas of sediment budget deficit (west of the structures). Additionally, there are sections of shoreline that are armored with steel-sheet piling and stone revetments, which have also altered natural shoreline conditions. The Calumet Harbor and River project and its associated dredging activities affect littoral drift in the Great Lakes resulting in sediment accretion and sediment budget deficits along the shoreline. Present dredging activities in the accretion areas, and beach nourishment activities in the areas with severe erosion, have helped lessen the existing impacts, but are not adequate to account for the annual sediment budget deficit, and do not fully address issues of sediment accretion. No future modifications to the shoreline have been identified within reaches 3 and 4, as most federal and industrial harbors and other man-made shoreline structures have already been constructed. Cumulative impacts on coastal processes under alternative A would be moderate, long-term and adverse.

Conclusion. Despite the continuation of the current dredging program and nearshore placement of sediment by the COE, under the no-action alternative, erosion would continue to affect Indiana Dunes National Lakeshore's sandscapes and shorelines. This would result in an overall minor to moderate, long-term, adverse impact. As erosion continues, the integrity of cultural and natural resources along the shoreline, as well as nearby infrastructure would be threatened. Additionally, existing navigational and industrial structures along the lakeshore would continue to interrupt sediment transportation. Cumulative impacts on coastal processes under alternative A would be moderate, long-term and adverse. Actions under alternative A would provide no incremental increase to the overall cumulative impacts.

Alternative C-1 (Beach Nourishment via Dredged Sources, Annual Frequency) – Preferred Alternative

Sediment Transport Processes. Under alternative C-1, sediment would be dredged from an updrift location placed annually on the beach at Portage Lakefront and Riverwalk. This would initially increase beach size within the placement area. The additional nourishment material would be sufficient to maintain the current shoreline position for approximately one year, as natural wave action would continue to erode the sediment after placement. The shorelines downdrift of the placement area at Portage Lakefront and Riverwalk would receive a large infusion of sediment following the material placement, affecting reach 4.

Transporting sediment from an updrift to a downdrift location mimics the natural processes, as material used would remain within the Lake Michigan system.

Implementing alternative C-1 therefore, would result in moderate, long-term, beneficial impacts as the sediment would be provided from an updrift source, more closely mimicking natural processes.

Dune Formation Processes. Under alternative C-1, sediment would be dredged from an updrift location in Lake Michigan and placed annually on the beach at Portage Lakefront and Riverwalk. Placement of the sediment would provide additional material available on land for aeolian (wind) transport, thus encouraging foredune development. Beach placement also would provide some buffering against storm events. The additional sediment on the beach would protect the current shoreline profile from increased erosion resulting from intense wave action, particularly during storm events.

Implementing alternative C-1 would result in moderate, long-term, beneficial impacts as the sediment placed on the beach, in conjunction with wind action, would allow for additional sediment supply to create foredunes.

Cumulative Impacts. Cumulative impacts under alternative C-1 would generally be as described for alternative A, with the exception that beach nourishment activities would include the amount of sediment needed to balance the annual sediment budget deficit. Cumulative effects would be negligible to minor, long-term and adverse.

Conclusion. Placing the proposed quantity of sediment on the beach in reach 3 would mitigate the sediment budget deficit, and thereby protect the current shoreline profile. Additionally, dredging sediment from an updrift location would more closely mimic natural processes as compared to using material from upland sources. Actions associated with alternative C-1 would also provide additional sediment to encourage foredune development along the shoreline, resulting in moderate, long-term, beneficial impacts on coastal processes. Cumulative impacts on coastal process would be negligible to minor, long-term and adverse.

Actions under alternative C-1 would provide incremental beneficial increases to the overall adverse cumulative impacts described under alternative A. Despite these actions, existing navigational and industrial structures along the lakeshore would continue to disrupt the natural littoral drift along the lakeshore.

Alternative C-5 (Beach Nourishment via Dredged Sources, Five-Year Frequency)

Sediment Transport Processes. Under alternative C-5, the five-year quantity of sediment to be placed on the beach in reach 3 would occur via dredging from an updrift location in Lake Michigan, such as near the NIPSCO/Bailly intake. The approximate 370,000 cubic yards (yd^3) of sediment would initially increase beach size along the length of reach 3, and would be sufficient to maintain the current shoreline position for approximately five years, as natural wave action would continue to erode the sediment after placement. The shoreline downdrift of reach 3 would receive a large infusion of sediment following the material placement, affecting reach 4. The large amount of sediment placed on the beach under alternative C-5 would increase the potential for there to be increased sedimentation at the Burns International Harbor, due to sediment transport along the lakeshore. If this occurred, it would create the need for increased dredging activities at the harbor. Additional studies and/or monitoring would be needed to evaluate the potential for this effect.

Transporting sediment from an updrift to a downdrift location would mimic the natural processes, as the material used would remain within the Lake Michigan system, resulting in moderate, long-term, beneficial impact. Potential issues with sedimentation at the Burns International Harbor would need to be evaluated, and would result in a minor to moderate, long-term, adverse impact.

Dune Formation Processes. Under alternative C-5, the five-year quantity of sediment to be placed on the beach in reach 3 would occur via dredging from an updrift location in Lake Michigan, such as near the NIPSCO/Bailly intake. This sediment would erode over the course of approximately five years. Placement of the sediment would provide additional material available on land for aeolian (wind) transport, thus encouraging foredune development. Placing the five-year quantity of sediment on the beach would result in additional protection against storm events. The additional sediment would protect the current shoreline profile from increased erosion resulting from intense wave action, particularly during winter weather. Implementing alternative C-5 would result in moderate to major, long-term, beneficial impacts, as the additional quantity of material on the beach, in conjunction with wind action, would encourage foredune development. The additional quantity of material would also provide buffering against intense weather events.

Cumulative Impacts. Cumulative impacts under alternative C-5 would generally be as described for alternative A, with the exception that beach nourishment activities would include the amount of sediment needed to balance the annual sediment budget deficit. The initial large amount of material placed on the beach would enhance conditions for dune formation, and provide greater protection to the beach complex from storm events. Cumulative effects would be negligible, long-term and adverse.

Conclusion. Placing the proposed quantity of sediment on the beach in reach 3 every five years would mitigate the sediment budget deficit and protect the current shoreline profile. Actions associated with alternative C-5 would also provide a large quantity of sediment on the beach from an updrift source to facilitate foredune development along the shoreline, resulting in moderate, long-term, beneficial impacts on coastal processes. Cumulative impacts on coastal process would be negligible, long-term and adverse. There would also be potential increased sedimentation at Burns International Harbor.

Actions under alternative C-5 would provide incremental beneficial increases to the overall adverse cumulative impacts described under alternative A. Despite these actions, existing navigational and industrial structures along the lakeshore would continue to disrupt the natural littoral drift along the lakeshore.

Alternative D (Beach Nourishment via Permanent Bypass System)

Sediment Transport Processes. Under alternative D, the amount of sediment material deposited in reach 3 would fulfill the estimated sediment budget deficit. A permanent bypass system would be constructed and operated to transport sediment from updrift of the NIPSCO/Baily complex to Portage Lakefront and Riverwalk. As with the previously described alternatives, implementing alternative D would place the additional sediment on the beach in reach 3. This would result in an initial increase in beach size within the placement area in front of Portage Lakefront and Riverwalk. The additional nourishment material would be sufficient to maintain the current shoreline position for approximately one year, as natural wave action would continue to erode the sediment after placement. The shoreline downdrift of Portage Lakefront and Riverwalk would receive an infusion of sediment following the material placement, affecting not only reach 3, but also reach 4.

Transporting sediment from an updrift to a downdrift location in this manner would mimic natural processes as material used in nourishment would remain within the Lake Michigan system, resulting in moderate, long-term, beneficial impacts.

Dune Formation Processes. Under alternative D, the amount of sediment material deposited in reach 1 would fulfill the estimated sediment budget deficit. A

permanent bypass system would be constructed and operated to transport sediment from updrift of the NIPSCO/Baily complex to Portage Lakefront and Riverwalk under this alternative. This sediment deposit would erode over the course of approximately one year. Placement of sediment on the beach is more effective than nearshore placement as additional material is available for aeolian (wind) transport, thus encouraging foredune development. Beach placement would provide some buffering against storm events. The additional sediment on the beach would protect the current shoreline profile from increased erosion resulting from intense wave action, particularly during storm events.

Implementing alternative D would result in moderate, long-term, beneficial impacts, as the sediment placed on the beach, in conjunction with wind action, would provide additional sediment supply to create foredunes.

Cumulative Impacts. Cumulative impacts for alternative D would generally be as described for alternative A, with the exception that beach nourishment activities would include the amount of sediment needed to balance the annual sediment budget deficit. Cumulative impacts would be negligible to minor, long-term and adverse.

Conclusion. Placing the proposed quantity of sediment on the beach in reach 3 would mitigate the sediment budget deficit, and thereby maintain the current shoreline profile. Additionally, dredging sediment from an updrift location would more closely mimic natural processes as compared to using material from upland sources. The actions associated with alternative D would also provide additional sediment to encourage foredune development along the shoreline, resulting in moderate, long-term, beneficial impacts on coastal processes. Cumulative impacts on coastal process would be negligible to minor, long-term and adverse.

Actions under alternative D would provide incremental beneficial increases to the overall adverse cumulative impacts described under alternative A. Despite these actions, existing navigational and industrial structures along the lakeshore would continue to disrupt the natural littoral drift along the lakeshore.

FOREDUNE AND DUNE COMPLEX, REACHES 1 THROUGH 4

Current and Proposed Management Actions

Current and proposed management actions for the foredune and dune complex address the issues of sensitive habitat restoration, invasive vegetation management, and anthropogenic influences. These actions primarily affect terrestrial resources. Management actions that would result in dune stabilization, such as revegetation with native plants and protection from pedestrian overuse (e.g., the realignment of trails), would encourage the dune formation processes. Also, as sediment is transported between the nearshore, beach, and dune complexes, improved conditions in the foredune and dune complex would enhance the natural sediment transport processes between these complexes. These actions would result in minor, long-term, beneficial impacts on coastal processes.

Cumulative Impacts. Cumulative impacts on the foredune and dune complex in reaches 1 through 4 under coastal processes as a result of proposed management actions would be negligible to minor, long-term, and beneficial from the enhanced natural sediment transport process that would result from the improved conditions in the foredune and dune complex.

Conclusion. Addressing sensitive habitat issues in the foredune and dune complex through site restoration, invasive vegetation management, and limiting and managing anthropogenic influences would result in dune stabilization from enhanced natural sediment transport processes, resulting in minor, long-term, beneficial impacts.

Cumulative impacts on the foredune and dune complex in reaches 1 through 4 under coastal processes would be negligible to minor, long-term, and beneficial from the enhanced natural sediment transport process that would result from the improved conditions in the foredune and dune complex.

AQUATIC FAUNA

METHODOLOGY

This analysis incorporates the best available scientific literature applicable to the region, the setting, and the actions being considered in the alternatives. Available information describing native, invasive and nonnative aquatic communities and distribution, including published scientific papers, NPS research reports, planning documents, state program materials, national databases and mapping efforts, and consultation with park specialists, were gathered, reviewed, and summarized. Impacts on aquatic fauna were evaluated by comparing projected changes resulting from the action alternatives to the projected results of implementing the no-action alternative.

Intensity Level Definitions

Intensity thresholds for native aquatic fauna are defined as follows:

Negligible: The impact is barely detectable, and/or would result in no noticeable or perceptible changes in encouraging native aquatic fauna presence.

Minor: The impact is slight but detectable, and/or would result in small but noticeable changes in encouraging native aquatic fauna presence.

Moderate: The impact is readily apparent, and would result in easily detectable changes in encouraging native aquatic fauna presence.

Major: The impact is severely adverse, or exceptionally beneficial, and/or would result in appreciable changes in encouraging native aquatic fauna presence.

SHORELINE AND BEACH COMPLEX, REACHES 1 AND 2

Alternative A (No-action Alternative)

Storm waves, capable of reaching the base of coastal dunes, cause massive erosion and slumping of dune sands. This, in turn, introduces large volumes of sediment into the nearshore sediment transport system. Fine dune sediment is held in suspension much longer than beach sediment or fill sediment, and could therefore, be transported farther offshore. Suspended solids in the water could affect fish populations by delaying the hatching time of fish eggs, killing the fish by abrading their gills, and causing anoxia. Fish tolerance to suspended solids varies from species to species and by age; however, destruction of habitat rather than suspension of sediments appears to be the major hazard to beach and nearshore fish. Most of these aquatic species have the ability to migrate from an undesirable environment and return when deposition ceases. Benthic fish (those living on or near the bottom of the lake) move into an area within the first day after a disturbance ceases. The motile aquatic species, that have stringent environmental requirements, such as substrate preferences for spawning, foraging, or shelter, as well as species closely associated with the beach for part of their life cycle (e.g., longnose dace [*Rhinichthys cataractae*]), would be most likely affected by beach nourishment (COE 1989). Species that form lake-bottom or benthic communities on most high-energy coastal beaches are adapted to periodic changes related to the natural erosion and accretion cycles and storms. Organisms adapted to unstable nearshore bottom conditions tend to tolerate perturbations better than those in more stable offshore environments. Areas of continued erosion and accretion would disturb spawning and nursery habitats in the nearshore.

Potential effects of beach nourishment include: altered distribution during offshore nourishment; potential for gill clogging and abrasion; temporary smoldering of benthic prey; burial of areas that serve as foraging and shelter sites; and potential burial of benthic fish. Burial of offshore benthic animals by beach nourishment material has a greater potential for adverse effects because the offshore organisms are more sensitive to perturbation than those in the upper nearshore and swash zone. Direct burial of nonmotile aquatic species in the placement area would produce localized mortality but would not have an appreciable effect of population stability (COE 1989).

Under alternative A, the natural processes occurring in the lake, though exacerbated by the modifications along the shoreline, would continue to provide nearshore habitat for the most disturbance-tolerant species. It is assumed that beach nourishment activities would continue, averaging approximately 31,500 yd^3 of mined material placed annually along the shoreline around Crescent Dune near Mount Baldy.

Meiofauna and macroinvertebrates — A 2006 study conducted in association with the current beach nourishment activities indicated that the benthic community affected by material deposition near Mount Baldy showed evidence of a relatively high rate of recovery within eight to 12 months after beach nourishment activities. Densities and total number of benthic taxa increased with depth, suggesting lower impact of sediment drift and wave action in deeper waters (Przybryla-Kelly and Whitman 2006). Since the benthic community within the beach nourishment placement area would recover within a year, impacts on the benthic community under the no-action alternative would be minor, short-term and adverse.

Fish of Lake Michigan — Yellow perch (*Perca flavescens*), as well as other fish species, are frequently found in the nearshore area, where wave-induced sediment transport is naturally active. It is well-recognized that these fish would vacate this nearshore area whenever a temporary natural disturbance occurred (e.g., the passage of a storm resulting in high wave activity and suspension of large quantities of sediment) and would return when favorable conditions were again present. Under the no-action alternative, the yellow perch population in the nearshore would be subjected to environmental stress arising from erosion and suspension of fine dune sands. The current beach nourishment program conducted by the COE was designed to combat this erosion. The average 31,500 yd^3 of material placed annually would be less than the calculated sediment budget deficit of 136,500 yd^3. Annual beach nourishment results in temporary displacement of fish as turbidity in the water column in both the dredge location and placement area would render the nearshore temporarily inhospitable. Under the no-action alternative, the erosion along the shoreline would continue, and fish assemblages in the nearshore area would remain subjected to environmental stress. Impacts on native fish species under alternative A would be minor, short-term and adverse.

Invasive and nonnative species — The presence of invasive and nonnative species, including round gobies and dreissenid mussels, changes native species composition. Dreissenid mussels compete directly with zooplankton for food because they filter phytoplankton from the water column. The decrease in zooplankton densities indirectly results in reduced numbers of age-0 yellow perch. Under the no-action alternative, beach nourishment activities would disturb the placement site, which would encourage the establishment of nonnative and invasive species at that site. This is because the sandy substrate of the lakeshore provides for benthic species and fish assemblages intertwined in a delicate food web that is easily disrupted by external forces, such as beach nourishment and placement activities like those currently taking place in reach 1. The sediment material used for such beach nourishment could provide a pathway for the establishment and introduction of nonnative species. Sediment

placement activities could also cause an unequal distribution of sediment supply to the lakeshore, resulting in a disturbed environment for aquatic fauna that encourages or invites nonnative and invasive species. The continued high rate of erosion taking place under the no-action alternative would result in loss of nearshore habitat, thus displacing native fish communities and encouraging a disturbed environment potentially more conducive to the presence of invasive and nonnative species. Effects on native species from the introduction and establishment of invasive and nonnative species would be negligible, long-term and adverse.

Cumulative Impacts. Several potential actions, independent of this plan, would affect the park's aquatic fauna. As described in the "Affected Environment" chapter, anthropogenic influences and alterations to the natural lake habitat have affected native aquatic species. The COE's electric barrier currently helps to block the passage of aquatic nuisance species between the Great Lakes and Mississippi River basins and beneficially discourages the presence of invasive and nonnative aquatic fauna. In the future, additional modifications to the nearby industrial and other properties may be made, which may affect the benthic community and fish assemblages along the Lake Michigan shoreline. Additionally, permitting requirements for industrial and federal discharges into the lake may change, becoming stricter or more lax. Ongoing river projects, like the Calumet Harbor and River project and its associated dredging activities and support of transit in the Great Lakes, may lead to future introductions of aquatic invasive species and continued disturbance to aquatic habitat. Additionally, ships' ballast water, which has accounted for 55% to 70% of reported aquatic invasive species introductions in to the Great Lakes since 1959, continues to provide a pathway for aquatic invasive species in to the Great Lakes. However, future introductions of aquatic invasive species may be effectively managed through ballast water exchange, saltwater flushing, or shipboard treatment, and through restricting access to the Great Lakes to vessels that have not taken protective measures to ensure they do not harbor aquatic invasive species.

Overall, these combined actions would have a moderate, long-term, adverse impact on the native aquatic species from disturbances to the natural lake habitat and from the pathways these activities introduce for aquatic invasive species. When combined with other past, present, and reasonably foreseeable future actions, implementing the no-action alternative would provide no incremental addition to the overall cumulative impacts on aquatic fauna.

Conclusion. Under the no-action alternative, nourishment activities would disturb the placement site, which would encourage the establishment of nonnative and invasive species at that site. In addition, the 31,500 yd^3 of nourishment material would not be sufficient to address the sediment deficit and beach erosion would continue. The actions proposed under the no-action alternative would result in negligible to minor, short- and long-term, adverse impacts on the native aquatic species. The overall cumulative impacts from invasive and nonnative aquatic fauna from past, present, and reasonably foreseeable future projects would be moderate, long-term and adverse. Under the no-action alternative, there would be no incremental addition to the overall cumulative impacts from disturbances to the nearshore lake habitat.

Alternative B-1 (Beach Nourishment via Upland Sources, Annual Frequency)

Under alternative B-1, the general effects of nourishment activities would be similar to those described under the no-action alternative. Under alternative B-1, nourishment activities would consist of 136,500 yd^3 of mined nourishment material being placed at Crescent Dune.

Meiofauna and macroinvertebrates — Under alternative B-1, impacts on benthic communities would be similar to those described under the no-action alternative, except that onshore placement of 136,500 yd^3 of beach nourishment material would temporarily smother benthic fauna at the placement location, which would consist of a greater area. As beach nourishment material would be from upland sources, there would be no disturbance to the aquatic habitat from dredging activities. In addition, the nourishment volume would match the sediment budget deficit and alleviate the adverse effects from erosion, thereby enhancing the aquatic habitat of the benthic communities. There would be fewer adverse effects from erosion of the shoreline, but the footprint of burial of benthic communities would be larger. Overall effects on the benthic community would be minor, short- and long-term, adverse and beneficial.

Fish of Lake Michigan — Under alternative B-1, effects on fish species would be similar to those described under the no-action alternative, except that under alternative B-1 there would be less erosion and less associated environmental stress to spawning and nursery habitats. Overall effects on fish species would be minor, long-term and beneficial because there would be less environmental stress from erosion and no disturbance from dredging. Under alternative B-1, the volume of beach nourishment material placed on reach 1 would cover a larger area and require longer placement times (approximately four months every year) than under the no-action alternative, resulting in a longer duration of turbid waters and thus longer periods of environmental stress for aquatic fauna. This annual beach nourishment would temporarily displace fish and result in minor, short-term, adverse effects on fish species.

Invasive and nonnative species — Invasive and nonnative aquatic species located in the nearshore of Lake Michigan would be affected similar to the native fish species. A largely homogenous sandy substrate would make the nearshore environment desirable to not only the native species, but to the invasive and nonnative aquatic species as well. Disruption of the natural environment typically would allow for introduction and establishment of nonnative and invasive species. Under alternative B-1, beach nourishment activities would disturb the placement site, which would encourage the establishment of nonnative and invasive species at that site. This is because the sandy substrate of the lakeshore provides for benthic species and fish assemblages that are easily disrupted by external forces, such as the beach nourishment activities that would take place under alternative B-1. Sediment placement activities could cause an unequal distribution of sediment supply to the lakeshore, resulting in a disturbed environment for aquatic fauna that would encourage or invite nonnative and invasive species. Appropriate beach nourishment material would be used, which would help mitigate attracting nonnative species. Therefore, under alternative B-1, effects from encouraging the presence of invasive and nonnative aquatic fauna would be similar to those described under the no-action alternative, except that over 105,000 yd^3 of additional beach nourishment material would be distributed on the beach. Impacts from invasive and nonnative aquatic species under alternative B-1 would be negligible, long-term and adverse.

Cumulative Impacts. Past, present, and reasonably foreseeable future projects with the potential to affect aquatic fauna would be similar to those described under the no-action alternative; moderate, long-term and adverse. Under alternative B-1, nourishment activities would beneficially add to the cumulative, long-term impacts. When combined with other past, present, and reasonably foreseeable future actions, implementing alternative B-1 would incrementally provide a beneficial effect from reducing erosion in the area, and a slight addition to the adverse effects from smothering benthic communities, displacing fish species and potentially encouraging the presence of invasive and nonnative aquatic fauna.

Conclusion. The actions proposed under alternative B-1 would result in negligible to minor, short- and long-term, adverse and beneficial impacts on the native aquatic species. The fish assemblages in the nearshore would be temporarily displaced and benthic communities would be smothered during beach nourishment activities. Also, nourishment activities would disrupt the nearshore environment, which would allow for the introduction and establishment of invasive and nonnative species, but overall the decreased erosion in the area would benefit benthic communities. The overall cumulative effects on aquatic fauna from past, present, and reasonably foreseeable future projects would be moderate, long-term and adverse. Under alternative B-1, there would be a slight incremental addition to the overall short-term, adverse cumulative impacts from smothering benthic communities, displacing fish species and potentially encouraging the presence of invasive and nonnative aquatic fauna.

Alternative B-5 (Beach Nourishment via Upland Sources, Five-Year Frequency)

Meiofauna and macroinvertebrates — Under alternative B-5, effects on the benthic community would be similar to those under alternative B-1. Placement of 682,500 yd^3 of sediment along the length of reach 1, would reduce erosion in the area, but would also smother benthic fauna within a greater footprint than under alternative B-1 and would last approximately 18 months every five years. The appropriate sediment placed during beach nourishment activities, in conjunction with effective timing, design and deposition rate, would reduce the adverse effects. Nonetheless, under alternative B-5, increasing the footprint of the placement area would result in burial of the benthic fauna along most of reach 1. The impacts under alternative B-5 would be moderate, long-term and adverse from smothering benthic communities, and minor, long-term and beneficial from reducing erosion.

Fish of Lake Michigan — Under alternative B-5, effects on fish species would be similar to those described under alternative B-1. Placement of 682,500 yd^3 of sediment along the length of reach 1 every five years would reduce erosion in the area, but would also displace fish and interrupt fish life cycles until turbidity in the water column subsided such that the area was once again inhabitable. Water turbidity would last for a longer period of time under alternative B-5 than under alternative B-1 because of the larger area of placement and the longer duration (approximately 18 months every five years) of placement activities. Therefore, under alternative B-5, impacts on fish species would be moderate, long-term and adverse from displacement due to water turbidity, and minor, long-term and beneficial from reducing erosion in the area and enhancing the fish habitat.

Invasive and nonnative species — Under alternative B-5, both native and nonnative/invasive benthic species would be temporarily affected by burial. Disruption of the natural environment would allow for introduction and establishment of nonnative and invasive species. Under alternative B-5, beach nourishment activities would disturb the placement site, which would encourage the establishment of nonnative and invasive species at that site. This is because the sandy substrate of the lakeshore provides for benthic species and fish assemblages that are easily disrupted by external forces, such as the beach nourishment activities that would take place under alternative B-5. Sediment placement activities could cause an unequal distribution of sediment supply to the lakeshore, resulting in a disturbed environment for aquatic fauna that would encourage or invite nonnative and invasive species. Risks from attracting nonnative species would be minimized because appropriate grain sized material would be used. Therefore, under alternative B-5, the effects from encouraging invasive and nonnative aquatic fauna would be negligible, long-term and adverse.

Cumulative Impacts. Past, present, and reasonably foreseeable future projects with the potential to affect aquatic fauna would be similar to those described under the no-action alternative: moderate, long-term and adverse. Under alternative B-5, beach nourishment activities would incrementally add to the cumulative long-term impacts. When combined with other past, present, and reasonably foreseeable future actions, implementing alternative B-5 would provide an incremental addition to the overall short-term, adverse cumulative impacts from smothering benthic communities, displacing fish species and potentially encouraging the presence of invasive and nonnative aquatic fauna.

Conclusion. The actions proposed under alternative B-5 would result in negligible to moderate, long-term, adverse and beneficial impacts on the native aquatic species. The fish assemblages in the nearshore would be temporarily displaced and benthic communities would be smothered during beach nourishment activities. Also, beach nourishment activities would disrupt the nearshore environment, which would allow for the introduction and establishment of invasive and nonnative species. Overall, the decreased erosion in the area would benefit benthic communities. The overall cumulative effects on aquatic fauna from past, present, and reasonably foreseeable future projects would be moderate, long-term and adverse. Under alternative B-5, there would be a slight incremental addition to the overall adverse cumulative impacts from smothering benthic communities, displacing fish species and potentially encouraging the presence of invasive and nonnative aquatic fauna.

Alternative C-1 (Beach Nourishment via Dredged Sources, Annual Frequency)

Meiofauna and macroinvertebrates — The effects on benthic communities under alternative C-1 would be similar to those described under alternative B-1 except that 136,500 yd^3 of beach nourishment material would be dredged from an updrift location and placed annually on the beach in reach 1.

Some research has shown that that the high-pressure (dredge) pipe kills most soft-bodied infaunal organisms, and animals that survive suspension only play a minor role in re-colonization. To enhance the chance of survival, sediment would closely match the native beach and would be applied slowly in a sheeting spray of sediment and water. This would allow organisms to keep up with the sediment overburdens as they were applied. As previously mentioned, literature reviews of beach nourishment impacts on beach biota indicate short-term declines in abundance, biomass, and taxa richness following beach nourishment. Recovery of the benthic community within the nearshore environment has been shown to occur within eight to 12 months after nourishment activities. Additionally, densities and total number of benthic taxa increased with depth, suggesting lower impact of sediment drift and wave action in deeper waters (Przybryla-Kelly and Whitman 2006).

Under alternative C-1, annual beach nourishment of the park shoreline with dredged material deposited onto the beach would have minor, short- and long-term, adverse and beneficial impacts on the benthic community in the placement area. There would be a long-term, beneficial effect from reducing erosion of the shoreline, but dredge activities would kill individual soft-bodied infaunal organisms. A high rate of recovery of the benthos would be expected in less than one year.

Fish of Lake Michigan — The effects on fish species under alternative C-1 would be similar to those described under alternative B-1 except that beach nourishment material would be dredged and pumped along reach 1. The turbidity in the water column would last longer because the volume of beach nourishment material placed on reach 1 under alternative C-1 would cover a larger area and

require longer placement times (approximately two months every year) than under the no-action alternative. This annual beach nourishment activity would temporarily displace fish and result in minor, short-term, adverse effects. Overall effects on fish species would be minor, long-term and beneficial because there would be less environmental stress from erosion.

Invasive and nonnative species — Dredging activities under alternative C-1 would disturb the natural environment and allow invasive and nonnative aquatic fauna to become established. Under alternative C-1, beach nourishment activities would disturb the placement site, which would encourage the establishment of nonnative and invasive species at that site. This is because the sandy substrate of the lakeshore provides for benthic species and fish assemblages that are easily disrupted by external forces, such as beach nourishment, placement, and dredging activities like those that would take place under alternative C-1. Sediment placement activities could also cause an unequal distribution of sediment supply to the lakeshore, resulting in a disturbed environment for aquatic fauna that would encourage or invite nonnative and invasive species. The dredged material would be similar in grain size distributions to those of the native beach and the grain size would closely match that of the natural beach sediments. Under alternative C-1, effects from encouraging the presence of invasive and nonnative aquatic fauna would be similar to those described under alternative B-1: negligible, short-term and adverse.

Cumulative Impacts. Past, present, and reasonably foreseeable future projects with the potential to affect aquatic fauna would be similar to those described under the no-action alternative: moderate, long-term and adverse. Under alternative C-1, beach nourishment activities would beneficially add to the cumulative, long-term impacts. When combined with other past, present, and reasonably foreseeable future actions, implementing actions under alternative C-1 would provide a slight incremental addition to the overall short-term, adverse cumulative impacts from smothering benthic communities, displacing fish species and potentially encouraging the presence of invasive and nonnative aquatic fauna.

Conclusion. The actions proposed under alternative C-1 would result in negligible to minor, short- and long-term, adverse and beneficial impacts on the native aquatic species. The fish assemblages in the nearshore would be temporarily displaced and benthic communities would be smothered during beach nourishment activities. Also, nourishment and dredging activities would disrupt the nearshore environment, which would allow for the introduction and establishment of invasive and nonnative species, but overall the decreased erosion in the area would benefit benthic communities. The overall cumulative effects on aquatic fauna from past, present, and reasonably foreseeable future projects would be moderate, long-term and adverse. Under alternative C-1, there would be a slight incremental addition to the overall short-term, adverse cumulative impacts from smothering benthic communities, displacing fish species and potentially encouraging the presence of invasive and nonnative aquatic fauna.

Alternative C-5 (Beach Nourishment via Dredged Sources, Five-Year Frequency)

Meiofauna and macroinvertebrates — Under alternative C-5, effects on the benthic community would be similar to those under alternative C-1. Placement of 682,500 yd^3 of sediment on the beach in reach 1 every five years would reduce erosion in the area, but would also smother benthic fauna within a greater footprint than under alternative C-1 and there would be greater mortality to individual soft-bodied infaunal organisms. The impacts under alternative C-5 would be moderate to major, short- and long-term, and

adverse from dredging activities and smothering benthic communities, and minor, long-term and beneficial from reducing the effects of erosion.

Fish of Lake Michigan — Under alternative C-5, effects on fish species would be similar to those under alternative C-1. Placement of 682,500 yd^3 of sediment along the length of reach 1 every five years would reduce erosion in the area, but would also displace fish and interrupt fish life cycles until turbidity in the water column subsided such that the area was once again inhabitable. Water turbidity would last for a longer period of time under alternative C-5 than under alternative C-1 because of the larger area of placement and the longer duration (approximately 10 months every five years) of dredging and placement activities. Therefore, under alternative C-5, impacts on fish species would be moderate to major, short- and long-term, and adverse from displacement due to water turbidity and dredging activities, and minor, long-term and beneficial from reducing erosion in the area and enhancing the fish habitat.

Invasive and nonnative species — Dredging activities under alternative C-5 would further disturb the natural environment, more so than under alternative C-1, and allow for the establishment of invasive and nonnative aquatic fauna. Therefore, under alternative C-5, effects from encouraging the presence of invasive and nonnative aquatic fauna would be negligible, short-term, and adverse.

Cumulative Impacts. Past, present, and reasonably foreseeable future projects with the potential to affect aquatic fauna would be similar to those described under the no-action alternative: moderate, long-term and adverse. Under alternative C-5, beach nourishment activities would beneficially add to the long-term, cumulative impacts. When combined with other past, present, and reasonably foreseeable future actions, implementing actions under alternative C-5 would provide a slight incremental addition to the overall short-term, adverse cumulative impacts from smothering benthic communities, displacing fish species and potentially encouraging the presence of invasive and nonnative aquatic fauna.

Conclusion. The actions proposed under alternative C-5 would result in negligible to major, short- and long-term, adverse and beneficial impacts on native aquatic species. The fish assemblages in the nearshore would be temporarily displaced and benthic communities would be smothered during beach nourishment activities. Also, beach nourishment and dredging activities would disrupt the nearshore environment, which would allow for the introduction and establishment of invasive and nonnative species, but overall the decreased erosion in the area would benefit benthic communities. The overall cumulative effects on aquatic fauna from past, present, and reasonably foreseeable future projects would be moderate, long-term and adverse. Under alternative C-5, there would be a slight incremental addition to the overall adverse, short-term, cumulative impacts from smothering benthic communities, displacing fish species and potentially encouraging the presence of invasive and nonnative aquatic fauna.

Alternative D (Beach Nourishment via Permanent Bypass System)

Meiofauna and macroinvertebrates — Under alternative D, on average, a total of 136,500 yd^3 of sediment would be transported via a permanent bypass system annually from updrift of the Michigan City Harbor to reach 1. The effects of implementing the high-pressure line associated with the permanent bypass system would be similar to those described under alternative C-1. There would be a minor, long-term, beneficial effect from reducing erosion of the shoreline, but the bypass system would kill individual soft-bodied infaunal organisms and cause minor, short-term impacts on benthic communities. Therefore, nourishment of the park shoreline with a sediment bypass system would have minor, short- and long-term, adverse and

beneficial impacts on the benthic community in the placement area.

Fish of Lake Michigan — Under alternative D, the effects on fish species would be similar to those described under alternative C-1 except that beach nourishment material would be pumped via a permanent bypass system. Implementing this beach nourishment system would result in temporary displacement of fish and produce minor, short-term, adverse effects. Overall effects on fish species would be minor, long-term and beneficial because there would be less environmental stress from erosion.

Invasive and nonnative species — The construction of the permanent bypass system would temporarily disrupt the natural environment and allow for the introduction of invasive and nonnative species. Invasive species, particularly round gobies and zebra mussels, would be attracted to artificial structures within the nearshore environment. There would be a slight change in the attraction of invasive and nonnative aquatic fauna. Under alternative D, effects from encouraging the presence of invasive and nonnative aquatic fauna would be negligible, long-term and adverse.

Cumulative Impacts. Past, present, and reasonably foreseeable future projects with the potential to affect invasive and nonnative aquatic fauna would be similar to those described under the no-action alternative: moderate, long-term and adverse. Under alternative D, beach nourishment activities and the permanent bypass system would incrementally add to the long-term, cumulative impacts. When combined with other past, present, and reasonably foreseeable future actions, actions under alternative D would provide an incremental addition to the overall adverse cumulative impacts from smothering benthic communities, displacing fish species and potentially encouraging the presence of invasive and nonnative aquatic fauna.

Conclusion. The actions proposed under alternative D would result in negligible to minor, short- and long-term, adverse and beneficial impacts on native aquatic species. The fish assemblages in the nearshore would be temporarily displaced and benthic communities would be smothered during beach nourishment activities. Also, construction of a permanent bypass system would disrupt the nearshore environment and allow for the introduction and establishment of invasive and nonnative species. Overall, the decreased erosion in the area would benefit benthic communities. The overall cumulative effects on aquatic fauna from past, present, and reasonably foreseeable future projects would be moderate, long-term and adverse. Under alternative D, there would be a slight incremental addition to the overall adverse cumulative impacts from smothering benthic communities, displacing fish species and encouraging the presence of invasive and nonnative aquatic fauna with the installation of a permanent bypass system.

Alternative E (Submerged Cobble Berm and Beach Nourishment, Annual Frequency)

Meiofauna and macroinvertebrates — The sandy substrate along the nearshore of the park shoreline supports a limited benthic community of low diversity. Increased densities have been noted in intermittent beds of cobble/gravel material. In the relatively high wave energy nearshore environment, at certain sediment-starved areas along the shoreline, particularly at the base of Mount Baldy, the clay substrate naturally found beneath the sediment has been exposed, and organic matter often found in calmer waters has been carried away from the shoreline (Garza and Whitman 2004). The kinetic nature of the nearshore environment has therefore created low density and diversity within the benthic community. One study, conducted from 1996 to 1998 in conjunction with a COE beach nourishment program, indicated that relatively few species

were detected in the benthic community inhabiting sandy substrates in the nearshore area, as indicated by the Shannon-Wiener and Margalef's diversity indices (Horvath *et al.* 1999).

The use of a submerged cobble berm in reach 1 would result in a longer retention of sediment within the nearshore. As the submerged cobble berm would begin to dissipate after construction, the aggregate material would disperse along the lakebed, creating a substrate inhabitable for benthic organisms. The nearshore environment at the base of Mount Baldy is currently identified with a lower benthic diversity and density as compared to other areas along the park shoreline (Garza and Whitman 2004). The implementation of alternative E within reach 1 would result in effects similar to those described under alternative C-1 because the submerged cobble berm would be used in conjunction with a beach nourishment program to restore reach 1 of Indiana Dunes National Lakeshore. These effects would be minor, short-term and adverse as the benthic fauna would be smothered during placement of the sediment. Impacts would be localized to the placement and construction area. There would be moderate, long-term and beneficial effects on the benthic community as the cobble material would both create additional habitat for these aquatic species and reduce erosion in the area. Longer retention of sediment and some organic material would allow for those species historically present in this area to re-colonize the area.

Fish of Lake Michigan — Under alternative E, the nearshore environment would be disrupted not only during the beach nourishment activities, but also during construction and placement of the submerged cobble berm, and during subsequent nourishment activities. The reduced quantity of beach nourishment material deposited annually in reach 1 would make the nearshore environment desirable to native species and invasive and nonnative aquatic species alike. The effects of the annual placement of nourishment material would be similar to those described under alternative C-1. As is the case with the benthic community in the nearshore, the presence of a submerged cobble berm in reach 1 would eventually provide a habitat for additional fish species not currently present in that area. In the initial years after construction during which the submerged cobble berm would be largely intact, wave energy would be dissipated, resulting in a calmer nearshore environment. Sediment retention time would increase, as would organic material and benthic organisms; both would be food sources for a variety of fish species. After the submerged cobble berm spread along the lake bottom, the aggregate material would potentially allow for more fish nurseries as the interstitial spaces would provide protection.

Ultimately, the implementation of alternative E would result in minor, short-term, adverse impacts as fish would be temporarily displaced during construction and beach nourishment activities. However, moderate, long-term, beneficial impacts would also result as the cobble material would enhance the aquatic fauna habitat.

Invasive and nonnative species — Invasive species, particularly round gobies and zebra mussels, would be attracted to artificial structures within the nearshore environment. Under alternative E, beach nourishment activities would disrupt the nearshore environment, which would allow for the introduction and establishment of invasive and nonnative species. Construction of the submerged cobble berm would also further attract invasive species. The cobble material and associated interstitial spaces in the submerged cobble berm would be an attractive habitat for invasive and nonnative species until the material dissipates and becomes covered by sediment. After the aggregate material dispersed along the lake bottom, zebra mussels' attraction to it would be minimized; however, additional invasive and nonnative aquatic species, such as the round goby, would continue to inhabit the area. Therefore, under alternative E, the

introduction of the submerged cobble berm into the nearshore environment would result in minor, long-term, adverse effects from encouraging invasive and nonnative aquatic fauna.

Cumulative Impacts. Past, present, and reasonably foreseeable future projects with the potential to affect aquatic fauna would be similar to those described under the no-action alternative: moderate, long-term and adverse. Under alternative E, nourishment activities and the submerged cobble berm would incrementally add both minor, short-term, adverse and minor, long-term, beneficial effects on cumulative impacts. When combined with other past, present, and reasonably foreseeable future actions, actions under alternative E would provide an incremental addition to the overall cumulative impacts by enhancing the habitat for benthic communities. These effects would be slightly countered by the enhancement of habitat for invasive and nonnative aquatic fauna as well.

Conclusion. The actions proposed under alternative E would result in moderate, short- and long-term, adverse and beneficial impacts on the native aquatic species. The aquatic fauna in the nearshore would be temporarily disturbed or displaced during construction of the submerged cobble berm and during beach nourishment activities. Long term, the aquatic habitat would be enhanced by providing protection and food sources for a variety of fish. The habitat would also be enhanced for nonnative and invasive species. The overall cumulative impacts on aquatic fauna from past, present, and reasonably foreseeable future projects would be moderate, long-term and adverse. Under this alternative, there would be an incremental addition to the overall cumulative effects by enhancing the habitat for benthic communities. These effects would be slightly countered by the enhancement of habitat for invasive and nonnative aquatic fauna as well.

Alternative F (Beach Nourishment, Annual Frequency with a Mix of Small Natural Stone at the Shoreline) – Preferred Alternative

Meiofauna and macroinvertebrates — Under alternative F, the use of an annual beach nourishment with a mix of small natural stone, dredged sediment, and coarse upland material would result in a longer retention of sediment within the nearshore. The objectives of adding the native stone to the nourishment material would be to stabilize the shoreline downdrift of the Michigan City Harbor by providing a more erosion resistant component, and to enhance aquatic habitat by diversifying the nearshore substrate consistent with dynamically stable reaches. The nearshore environment at the base of Mount Baldy is currently identified with a lower benthic diversity and density as compared to other areas along the park shoreline (Garza and Whitman 2004). The implementation of alternative F within reach 1 would result in effects similar to those described under alternative C-1 because the beach nourishment program with a mix of small natural stone, dredged sediment, and coarse upland material would be utilized to restore reach 1 of Indiana Dunes National Lakeshore. These effects would be minor, short-term and adverse as the benthic fauna would be smothered during placement of the sediment. Impacts would be localized to the placement and construction area. There would be moderate, long-term and beneficial effects on the benthic community as the small natural stones would both create additional habitat for these aquatic species and reduce erosion in the area. Longer retention of sediment and some organic material would allow for those species historically present in this area to re-colonize the area

Fish of Lake Michigan — Under the preferred alternative, the nearshore environment would be disrupted during the beach nourishment activities. The effects of the annual placement of nourishment material would be similar to those described under alternative C-1.

As is the case with the benthic community in the nearshore, the presence of small natural stone mixed in the beach nourishment would provide a habitat for additional fish species not currently present in that area. Sediment retention time would increase, as would organic material and benthic organisms; both would be food sources for a variety of fish species.

Ultimately, the implementation of the preferred alternative would result in minor, short-term, adverse impacts as fish would be temporarily displaced during beach nourishment activities. However, moderate, long-term, beneficial impacts would also result as the nourishment material would enhance the aquatic fauna habitat.

Invasive and nonnative species — Under the preferred alternative, beach nourishment activities would temporarily disrupt the nearshore environment. Dispersion of small stones would provide habitats consistent with those of dynamically stable reaches. Existing populations of nonnative species such as the round goby will neither benefit nor be hindered. Population densities would be expected to be consistent with those already existing at dynamically stable reaches. Therefore under the preferred alternative the introduction of the native stone into the nearshore environment would result in minor long-term adverse effects from encouraging invasive and nonnative aquatic fauna.

Cumulative Impacts. Past, present, and reasonably foreseeable future projects with the potential to affect aquatic fauna would be similar to those described under the no-action alternative: moderate, long-term and adverse. Under the preferred alternative, beach nourishment activities with a mix of small natural stone, dredged sediment, and coarse upland material would incrementally add both minor, short-term, adverse and minor, long-term, beneficial effects on cumulative impacts. When combined with other past, present, and reasonably foreseeable future actions, actions under the preferred alternative would provide an incremental addition to the overall cumulative impacts by enhancing the habitat for benthic communities. These effects would be slightly countered by the enhancement of habitat for invasive and nonnative aquatic fauna as well.

Conclusion. The actions proposed under the preferred alternative would result in moderate, short- and long-term, adverse and beneficial impacts on the native aquatic species. The aquatic fauna in the nearshore would be temporarily disturbed or displaced during during beach nourishment activities. Long term, the aquatic habitat would be enhanced by providing protection and food sources for a variety of fish. The habitat would also be enhanced for nonnative and invasive species. The overall cumulative impacts on aquatic fauna from past, present, and reasonably foreseeable future projects would be moderate, long-term and adverse. Under the preferred alternative, there would be an incremental addition to the overall cumulative effects by enhancing the habitat for benthic communities. These effects would be slightly countered by the enhancement of habitat for invasive and nonnative aquatic fauna as well.

SHORELINE AND BEACH COMPLEX, REACHES 3 AND 4

Alternative A (No-action Alternative)

Storm waves, capable of reaching the base of coastal dunes, cause massive erosion and slumping of dune sands. This, in turn, causes large volumes of fine sand to be carried into the nearshore sediment transport system. Fine dune sand is held in suspension much longer than natural beach sediment or fill sediment and could, therefore, be transported farther offshore. Suspended solids in the water could affect fish populations by delaying the hatching time of fish eggs, killing the fish by abrading their gills, and causing anoxia. Fish tolerance to suspended solids varies from species to species and by age. Destruction of habitat rather than suspension of sediments appears to be the major hazard to beach and nearshore fishes. Most of these aquatic

species have the ability to migrate from an undesirable environment and return when turbidity levels in the water column have decreased, and living conditions are once again present. Several long-term studies have shown that moderate to complete recovery of motile animal populations has occurred in less than a year. These studies have shown that motile aquatic species generally temporarily depart an area disturbed by beach nourishment, but return when the physical disturbance ceases. Benthic fish move into an area within the first day after a disturbance. The motile aquatic species that have stringent environmental requirements, such as substrate preferences for spawning, foraging, or shelter, are most likely to be affected (COE 1989). Therefore, species that are closely associated with the beach for part of their life cycle are most affected by beach nourishment (COE 1989). Species that form lake-bottom or benthic communities on most high-energy coastal beaches are adapted to periodic changes related to the natural erosion and accretion cycles and storms. Organisms adapted to unstable nearshore bottom conditions tend to tolerate perturbations better than those in more stable offshore environments.

Potential effects of beach nourishment include: altered distribution during offshore nourishment; potential for gill clogging and abrasion; temporary smoldering of benthic prey; burial of areas that serve as foraging and shelter sites; and potential burial of benthic (living on or near the bottom of the lake) fish. Burial of offshore benthic animals by beach nourishment material has a greater potential for adverse effects because the offshore organisms are more sensitive to perturbation than those in the upper nearshore and swash zone. Direct burial of nonmotile aquatic species in the placement area could be lethal to the individual. Effects of direct burial of aquatic fauna are not generally substantial at the population or community level, unless it is a sensitive resource (COE 1989).

Under alternative A, the natural processes occurring in the lake, though exacerbated by the modifications along the shoreline, would continue to provide nearshore habitat for the most disturbance-tolerant species. Beach nourishment activities would consist of 74,000 yd^3 of dredged material placed within open water between 12 and 18 feet of water depth near reach 3.

Meiofauna and macroinvertebrates — The lake substrate in reach 3 is largely homogenous and composed of sand; there is relatively little diversity and low density of benthic fauna. Under the no-action alternative, erosion would continue at an accelerated rate which would threaten the aquatic nearshore environment. As wave dynamics in this area are such that only the most disturbance-prone organisms could survive, the benthic community would remain affected by natural processes. The nearshore placement of dredged sediment would result in minor, short-term, adverse impacts on the benthic fauna in the nearshore as they would be smothered during placement of sediment. Impacts would be localized to the placement area.

Fish of Lake Michigan — Without nourishment material on the beach, the fish population in the nearshore would be subjected to an adverse environmental stress, arising from the erosion and suspension of fine dune sands. The current nearshore placement conducted by the COE was designed to combat the continued erosion of the shoreline along Portage Lakefront and Riverwalk. Erosion along the shoreline would continue, and fish assemblages in the nearshore would continue to be subjected to the environmental stress associated with erosion in the area. Nearshore nourishment placement would temporarily displace fish, as turbidity in the water column of the placement area would render the nearshore temporarily inhospitable. Impacts on native fish species under alternative A would therefore be minor, short-term and adverse.

Invasive and nonnative species — Under the no-action alternative, beach nourishment activities would disturb the placement site,

which would encourage the establishment of nonnative and invasive species at that site. This is because the sandy substrate of the lakeshore provides for benthic species and fish assemblages intertwined in a delicate food web that is easily disrupted by external forces, such as beach nourishment and placement activities like those currently taking place in reach 3. The sediment material used for such beach nourishment could provide a pathway for the establishment and introduction of nonnative species. Sediment placement activities could also cause an unequal distribution of sediment supply to the lakeshore, resulting in a disturbed environment for aquatic fauna that encourages or invites nonnative and invasive species. Under the no-action alternative, the effects on native populations from encouraging the presence of invasive and nonnative species would be negligible, short-term and adverse.

Cumulative Impacts. Several potential actions, independent of this plan, would affect the park's aquatic fauna. As described in the "Affected Environment" chapter, anthropogenic influences and alterations to the natural lake habitat have affected native aquatic species. The COE's electric barrier currently helps to block the passage of aquatic nuisance species between the Great Lakes and Mississippi River basins and beneficially discourages the presence of invasive and nonnative aquatic fauna. In the future, additional modifications to nearby industrial and other properties may be made, which may affect the benthic community and fish assemblages along the Lake Michigan shoreline. Additionally, permitting requirements for industrial and federal discharges into the lake may change, becoming stricter or more lax. Ongoing river projects, like the Calumet Harbor and River project and its associated dredging activities and support of transit in the Great Lakes, may lead to future introductions of aquatic invasive species in the Great Lakes and continued disturbance to aquatic habitat. Additionally, ships' ballast water, continues to provide a pathway for aquatic invasive species in to the Great Lakes. However, future introductions of aquatic invasive species may be effectively managed through ballast water exchange, saltwater flushing, or shipboard treatment, and through restricting access to the Great Lakes to vessels that have not taken protective measures to ensure they do not harbor aquatic invasive species.

Overall, these combined actions would have a moderate, long-term, adverse impact on the native aquatic species from disturbances to the natural lake habitat and from the pathways these activities introduce for aquatic invasive species. When combined with other past, present, and reasonably foreseeable future actions, implementing the no-action alternative would provide no incremental addition to the overall cumulative impacts on aquatic fauna.

Conclusion. Under the no-action alternative, beach nourishment activities would disrupt the nearshore environment, which would allow for the introduction and establishment of invasive and nonnative species. In addition, the 74,000 yd^3 of beach nourishment material placed in open water would not alleviate beach erosion in the area. The actions proposed under the no-action alternative would result in negligible to minor, short-term, adverse impacts on native aquatic species. The overall cumulative impacts on aquatic fauna from past, present, and reasonably foreseeable future projects would be moderate, long-term and adverse. Under the no-action alternative, there would be no incremental addition to the overall existing cumulative impacts.

Alternative C-1 (Beach Nourishment via Dredged Sources, Annual Frequency) – Preferred Alternative

Under alternative C-1, the general effects of beach nourishment activities would be similar to those described under the no-action alternative. Under alternative C-1, nourishment activities would consist of 74,000 yd^3 of dredged beach nourishment material

being placed annually on the beach at Portage Lakefront and Riverwalk.

Meiofauna and macroinvertebrates — Under the preferred alternative, impacts on benthic communities would be similar to those described under the no-action alternative, except that placement of 74,000 yd^3 of beach nourishment material would be hydraulically pumped onshore. Some research has shown that the high-pressure (dredge) pipe kills most soft-bodied infaunal organisms, and animals that survive suspension only play a minor role in re-colonization. To enhance the chance of survival, sediment would closely match the native beach and would be applied slowly in a sheeting spray of sediment and water. This would allow organisms to keep up with the sediment overburdens as they were applied. Literature reviews of beach nourishment impacts to beach biota indicate short-term declines in abundance, biomass, and taxa richness following beach nourishment. Recovery of the benthic community within the nearshore environment has been shown to occur within eight to 12 months after nourishment activities. Additionally, densities and total number of benthic taxa increased with depth, suggesting lower impact of sediment drift and wave action in deeper waters (Przybryla-Kelly and Whitman 2006). Therefore, under alternative C-1, annual nourishment of the park shoreline with dredged material deposited onto the beach would have minor, short- and long-term, adverse and beneficial impacts on the benthic community in the placement area. There would be a minor, long-term, beneficial effect from reducing erosion of the shoreline, but the dredge would kill individual soft-bodied infaunal organisms. A high rate of recovery of the benthos would be expected within less than one year.

Fish of Lake Michigan — Under alternative C-1, effects on fish species would be similar to those described under the no-action alternative, except under alternative C-1 there would be less erosion and less associated environmental stress to spawning and nursery habitats. Effects on fish species would be minor, long-term, and beneficial because there would be less environmental stress. Under alternative C-1, the volume of beach nourishment material placed on reach 3 would cover a larger area and require longer placement times (approximately two months every year) than under the no-action alternative, resulting in a longer duration of turbid waters and thus longer periods of environmental stress for aquatic fauna. This annual beach nourishment would temporarily displace fish and result in minor, short-term, adverse effects on fish species.

Invasive and nonnative species — Invasive and nonnative aquatic species located in the nearshore of Lake Michigan would be affected similar to the native fish species. A sandy substrate would make the nearshore environment desirable to not only the native species, but the invasive and nonnative aquatic species as well. Disruption of the natural environment typically allows for introduction and establishment of nonnative and invasive species. Under alternative C-1, beach nourishment activities would disturb the placement site, which would encourage the establishment of nonnative and invasive species at that site. This is because the sandy substrate of the lakeshore provides for benthic species and fish assemblages that are easily disrupted by external forces, such as beach nourishment, placement, and dredging activities like those that would take place under alternative C-1. Sediment placement activities could also cause an unequal distribution of sediment supply to the lakeshore, resulting in a disturbed environment for aquatic fauna that would encourage or invite nonnative and invasive species. Appropriate beach nourishment material would be used, which would help mitigate attracting nonnative species. Therefore, under alternative C-1, effects from encouraging the presence of invasive and nonnative aquatic fauna would be similar to those described under the no-action alternative and would be negligible, short-term and adverse.

Cumulative Impacts. Past, present, and reasonably foreseeable future projects with the potential to affect aquatic fauna would be similar to those described under the no-action alternative: moderate, long-term and adverse. Under the preferred alternative, beach nourishment activities would beneficially add to the long-term, cumulative impacts by reducing erosion in the area and enhancing the aquatic habitat. When combined with other past, present, and reasonably foreseeable future actions, actions under alternative C-1 would provide a slight incremental addition to the overall short-term, adverse cumulative impacts from smothering benthic communities, displacing fish species and potentially encouraging the presence of invasive and nonnative aquatic fauna.

Conclusion. The actions proposed under alternative C-1 would result in negligible to minor, short- and long-term, adverse and beneficial impacts on native aquatic species. The fish assemblages in the nearshore would be temporarily displaced and benthic communities would be smothered during beach nourishment activities. Also, nourishment and dredging activities would disrupt the nearshore environment, which would allow for the introduction and establishment of invasive and nonnative species, but overall the decreased erosion in the area would benefit benthic communities. The overall cumulative effects on aquatic fauna from past, present, and reasonably foreseeable future projects would be moderate, long-term and adverse. Under alternative C-1, there would be a slight incremental addition to the short-term, adverse cumulative impacts from smothering benthic communities, displacing fish species and potentially encouraging the presence of invasive and nonnative aquatic fauna.

Alternative C-5 (Beach Nourishment via Dredged Sources, Five-Year Frequency)

Under alternative C-5, the general effects of beach nourishment activities would be similar to those described under the no-action alternative. Under alternative C-5, beach nourishment activities would consist of 370,000 yd^3 of sediment being dredged from an updrift location in Lake Michigan, such as near the NIPSCO/Bailly intake, once every five years.

Meiofauna and macroinvertebrates — Under alternative C-5, effects on the benthic community would be similar to those under alternative C-1. Placement of 370,000 yd^3 of sediment along Portage Lakefront and Riverwalk at reach 3 once every five years would reduce erosion in the area, but would also smother benthic fauna within a greater footprint than that under alternative C-1. In addition, there would be greater mortality to individual soft-bodied infaunal organisms from the hydraulic pumping of beach nourishment material. Therefore, the impacts on benthic communities under alternative C-5 would be moderate to major, short- and long-term, and adverse due to the duration (i.e., approximately six months every five years) and extent of the beach nourishment placement, and effects from reducing erosion in the area would be minor, long-term and beneficial.

Fish of Lake Michigan — Under alternative C-5, effects on fish species would be similar to those under alternative C-1. Placement of 370,000 yd^3 of sediment every five years would reduce erosion in the area, but would also displace fish and interrupt fish life cycles until turbidity in the water column subsided such that the area was once again inhabitable. Water turbidity would last for a longer period of time under alternative C-5 than under alternative C-1 because of the larger area of placement and the longer duration (approximately six months every five years) of dredging and placement activities. Therefore, under alternative C-5, impacts on fish species

would be moderate to major, short- and long-term, and adverse from displacement due to water turbidity and dredging activities, and minor, long-term, and beneficial from reducing erosion in the area and enhancing the fish habitat.

Invasive and nonnative species — Dredging/pumping activities under alternative C-5 would further disturb the natural environment, more so than under alternative C-1, and allow for the establishment of invasive and nonnative aquatic fauna. Under alternative C-5, beach nourishment activities would disturb the placement site, which would encourage the establishment of nonnative and invasive species at that site. Beach nourishment, placement, and dredging activities like those that would take place under alternative C-1 would disturb the aquatic fauna environment. Sediment placement activities could also cause an unequal distribution of sediment supply to the lakeshore, resulting in a disturbed environment for aquatic fauna that would encourage or invite nonnative and invasive species. Therefore, under alternative C-5, effects from encouraging the presence of invasive and nonnative aquatic fauna would be negligible, short-term, and adverse.

Cumulative Impacts. Past, present, and reasonably foreseeable future projects with the potential to affect invasive and nonnative aquatic fauna would be similar to those described under the no-action alternative: moderate, long-term and adverse. Under alternative C-5, nourishment activities would incrementally add to the long-term, beneficial, cumulative impacts by reducing the adverse effects of erosion in the area. When combined with other past, present, and reasonably foreseeable future actions, the actions under alternative C-5 would also provide an incremental addition to the overall short-term, adverse cumulative impacts from displacing or disturbing native fish species and encouraging the presence of invasive and nonnative aquatic fauna.

Conclusion. The actions proposed under alternative C-5 would result in negligible to major, short- and long-term, adverse and beneficial impacts on the native aquatic species. Fish assemblages would be displaced, and fish life cycles would be interrupted. Also, beach nourishment and dredging activities would disrupt the nearshore environment, which would allow for the introduction and establishment of invasive and nonnative aquatic fauna. The overall cumulative impacts on aquatic fauna from past, present, and reasonably foreseeable future projects would be moderate, long-term and adverse. Implementing the actions under alternative C-5 would provide an incremental addition to the overall short-term, adverse and beneficial, cumulative impacts, as effects from erosion in the area would be lessened, but there would be disturbances to the aquatic communities during beach nourishment activities.

Alternative D (Beach Nourishment via Permanent Bypass System)

Meiofauna and macroinvertebrates — Under alternative D, 74,000 yd^3 of sediment would be transported via a permanent bypass system from updrift of the NIPSCO/Bailly complex and be placed on the beach at Portage Lakefront and Riverwalk. The effects of the high-pressure line associated with the permanent bypass system would be similar to those described under alternative C-1. There would be a minor, long-term, beneficial effect from reducing erosion of the shoreline, but the bypass system would kill individual soft-bodied infaunal organisms and cause minor, short-term, adverse impacts on benthic communities. Therefore, nourishment of the park shoreline with a sediment bypass system would have minor, short- and long-term, adverse and beneficial impacts on the benthic community in the placement area.

Fish of Lake Michigan — The effects on fish species under alternative D would be similar to those described under alternative C-1, except that beach nourishment material would be pumped via a permanent bypass

system. This nourishment system would temporarily displace fish, resulting in minor, short-term, adverse effects. Overall effects on fish species would be minor, long-term and beneficial because there would be less environmental stress from erosion.

Invasive and nonnative species — The construction of the permanent bypass system would temporarily disrupt the natural environment and allow for the introduction of invasive and nonnative species. Invasive species, particularly round gobies and zebra mussels, would be attracted to artificial structures within the nearshore environment. There would be an easily detectible change in the attraction of invasive and nonnative aquatic fauna. Under alternative D, effects from encouraging the presence of invasive and nonnative aquatic fauna would be negligible, long-term and adverse.

Cumulative Impacts. Past, present, and reasonably foreseeable future projects with the potential to affect invasive and nonnative aquatic fauna would be similar to those described under the no-action alternative: moderate, long-term and adverse. Under alternative D, beach nourishment activities and the permanent bypass system would incrementally add to the long-term, cumulative impacts. When combined with other past, present, and reasonably foreseeable future actions, actions implemented under alternative D would provide an incremental addition to the overall short-term, adverse cumulative impacts from smothering benthic communities, displacing fish species and potentially encouraging the presence of invasive and nonnative aquatic fauna.

Conclusion. The actions proposed under alternative D would result in negligible to minor, short- and long-term, adverse and beneficial impacts on native aquatic species. The fish assemblages in the nearshore would be temporarily displaced and benthic communities would be smothered during beach nourishment activities. Also, construction activities would disrupt the nearshore environment, which would allow for the introduction and establishment of invasive and nonnative species. Overall, the decreased erosion in the area would benefit benthic communities. The overall cumulative effects on aquatic fauna from past, present, and reasonably foreseeable future projects would be moderate, long-term and adverse. Under alternative D, there would be a slight incremental addition to the overall short-term, adverse cumulative impacts from smothering benthic communities, displacing fish species and encouraging the presence of invasive and nonnative aquatic fauna with the installation of a permanent bypass system.

FOREDUNE AND DUNE COMPLEX, REACHES 1 THROUGH 4

Current and Proposed Management Actions

Current and proposed management actions for the foredune and dune complex address issues with sensitive habitat restoration, invasive vegetation management, and anthropogenic influences. These are actions that primarily affect terrestrial resources. Management actions that would result in reduced erosion in the area, such as revegetation with native plants and protection from pedestrian overuse, would reduce the volume of fine sand that would carried into the nearshore sediment transport system and would thereby beneficially enhance the aquatic habitat. These actions would result in minor, long-term, beneficial impacts on aquatic fauna.

Cumulative Impacts. Cumulative impacts on the foredune and dune complex in reaches 1 through 4 under aquatic fauna as a result of proposed management actions would be negligible to minor, long-term, and beneficial from the reduced erosion in the area and reduced volume of fine sediment that would be carried into the nearshore sediment transport system, beneficially enhancing the aquatic habitat.

Conclusion. Addressing sensitive habitat issues in the foredune and dune complex through site restoration, invasive vegetation management, and limiting and managing anthropogenic influences positively affect terrestrial resources and would result in minor, long-term, beneficial impacts on aquatic fauna. Cumulative impacts on the foredune and dune complex in reaches 1 through 4 under aquatic fauna would be negligible to minor, long-term, and beneficial from the enhanced aquatic habitat.

TERRESTRIAL HABITAT

METHODOLOGY

Impacts on plant and animal terrestrial habitat were evaluated by comparing projected changes that would result from implementing the action alternatives to taking no action (i.e., the no-action alternative). Information about native terrestrial habitat in the park was compiled from site visits, publicly available research data, information from park staff, and studies of similar actions and effects. Impacts on terrestrial habitat were assessed qualitatively based on the project team's knowledge and best professional judgment.

A discussion of potential effects on wildlife necessarily involves discussion of wildlife habitat, which is primarily the vegetation communities within the park. Potential effects to terrestrial invertebrates, birds, amphibians and reptiles, and mammals are based on assessed effects to native plant communities because the park's wildlife species are directly affected by the natural abundance, biodiversity, and the ecological integrity of the vegetation that composes their habitat. Effects from noise on wildlife are addressed under the "Soundscape" section of the "Environmental Consequences" chapter.

Intensity Level Definitions

Intensity thresholds for terrestrial habitat are defined as follows:

Negligible: The impact is barely detectable and/or would result in no noticeable or perceptible changes in encouraging terrestrial habitat for plant and animal communities.

Minor: The impact is slight but detectable and/or would result in small but noticeable changes in encouraging terrestrial habitat for plant and animal communities.

Moderate: The impact is readily apparent and would result in easily detectable changes in encouraging terrestrial habitat for plant and animal communities.

Major: The impact is severely adverse or exceptionally beneficial, and/or would result in appreciable changes in encouraging terrestrial habitat for plant and animal communities.

SHORELINE AND BEACH COMPLEX, REACHES 1 AND 2

Alternative A (No-action Alternative)

Under the no-action alternative, there would be no new impacts on the terrestrial habitat of native plant and animal communities in the park, and the actions associated with this alternative would neither invite nor deter invasive species from inhabiting the shoreline and beach complex in reaches 1 and 2. Under this alternative, the current trend of destabilization of the foredunes would continue, increasing the risk to Mount Baldy. Such destabilization would lead to the localized loss of the natural ecosystems associated with the beach and the foredunes, including plant species endemic to the dunes, as well as insects, reptiles, birds and mammals dependent upon this habitat. These actions would have minor, short- and long-term, adverse impacts on terrestrial habitat. In addition, the western terminus of reach 1 would continue to be infested with nonnative trees. Continued erosion and degradation would invite colonization by these species and other nonnative invasive plants, having a minor, long-term, adverse impact on terrestrial habitat for native plant and animal communities.

Under the no-action alternative, current beach nourishment activities in reach 1 would forestall continued erosion and degradation around Mount Baldy. The amount of sediment added to the shoreline would be

inadequate to offset the deficit under this alternative. Therefore, the erosion and degradation of the foredune would continue, thus jeopardizing plant species endemic to the foredune complex. The actions associated with the no-action alternative would have minor, short- and long-term, adverse impacts on native plant and animal communities, as some beach vegetation would be smothered by sediment placement during beach nourishment activities and loss of critical terrestrial habitat would continue. With no new actions being taken under alternative A, storm events would continue to cause substantial erosion in the park to the detriment of terrestrial habitat for plant and animal communities.

Cumulative Impacts. Several actions, independent of this plan, would affect the park's terrestrial habitat for plant and animal communities. As described in the "Affected Environment" chapter, much of the terrestrial habitat for native plant communities in the park, including species of conservation concern, has been altered by invasive vegetation and anthropogenic influences.

The Michigan City Harbor, Burns International Harbor, and the Gary-U.S. Steel man-made structures that were constructed in and around the project area continue to interrupt natural processes with minor, long-term, adverse effects on the terrestrial habitat for native plant and animal communities because of the changes to natural sediment accumulation that these cause. The designation of the appropriate route to and from Mount Baldy from the parking lot by the park resulted in minor, long-term, beneficial impacts on native plant and animal communities by reducing the social trails in reach 1, thus reducing the trampling of native plants in this area and the introduction of invasive plant species to this reach.

Development projects, past, present, and future, like those that occurred under Phase I of the Marquette Plan and those that are proposed under Phase II of that plan, would have minor to moderate, short- and long-term, adverse impacts on native plant vegetation. Construction work often results in the loss and modification of vegetation in construction areas, and potentially introduces invasive and nonnative plant species. The spread of nonnative and invasive plant species in the park has been a problem. Pathways that could introduce nonnative and invasive plant species in to the park include construction and visitor activities, as well as natural sources such as wind and bird migration. It is difficult to determine the impact of nonnative species on native vegetation due to the uncertainties about the type of species that could be introduced, as well as the locations and frequencies of the introductions. Despite monitoring and management efforts, the impact of the introduction and establishment of nonnative species in the park would range from minor to moderate, and would be long-term and adverse.

Ongoing clean sediment beach nourishment activities in reach 1 are performed on an intermittent basis. These activities impact sediment deposition, and have a minor, short-term, beneficial impact on native plant and animal communities from the reduced erosion that results. "Clean" beach nourishment also reduces the likelihood of introduction of invasive and nonnative plant species into the park.

Restoration work in the park, including invasive vegetation management through the early detection and rapid response program and Invasive Plant Management Plan and fencing off highly eroded and environmentally sensitive areas on Mount Baldy, stabilizes select areas of eroded areas in the park with native vegetation. This work would have minor, long-term, beneficial impacts on native plant and animal communities by preserving the natural physiography of the land and restoring lands to their natural states. Similarly, efforts to expand visitor outreach and education opportunities in the park would have minor, long-term, beneficial impacts on native plant and animal communities from the reduction in vegetation trampling and destruction of habitat. Future

realignment of trails would result in minor, long-term, beneficial impacts on terrestrial habitat for native plant and animal communities from reducing social trails (leading to less trampling and the reduced likelihood of introduction of invasive nonnative plant species in the park); though this work would involve negligible to minor, short-term, adverse impacts during construction and re-alignment work due to the temporary disturbance to habitat.

Overall, when the actions described above are added to the existing environment for terrestrial habitat, there would be minor, short- and long-term, adverse and beneficial, cumulative impacts. The actions under alternative A would add a small increment to the overall cumulative impact.

Conclusion. Under alternative A, there would continue to be minor, short- and long-term, adverse impacts on the terrestrial habitat of native plant and animal communities from the erosion and destabilization that would result from taking no new actions in the park. Cumulatively, there would be minor to moderate, short- and long-term, adverse and beneficial, cumulative impacts on the terrestrial habitat of native plant and animal communities. Adverse impacts would result from continued degradation of habitat that would result from ongoing erosion; beneficial impacts would result from restoration efforts that preserve natural plant and animal habitat in the park. Implementing the actions under alternative A would result in a small increment being added to the overall cumulative impact.

Alternative B-1 (Beach Nourishment via Upland Sources, Annual Frequency)

The actions associated with alternative B-1 would allow for increased beachfront, thereby providing the potential for a stabilized dune complex, particularly at Mount Baldy. Foredune development under this alternative would be feasible with sediment supply, wind, and an entrapment feature, such as vegetation. In conjunction with the restoration option selected, terrestrial management practices, such as revegetation in areas of beach erosion, would promote the formation of foredunes. These embryotic dunes would protect leeward dunes, pannes, and other ecological features; provide habitat connectivity and sustainability; and contribute sediment (via natural erosion) to the coastal system. These actions would result in minor, short-term, beneficial impacts on the terrestrial habitat for native plant and animal communities. Nourishment of the park shoreline, particularly in areas of accelerated erosion, would result in minor, short-term, beneficial impacts on the terrestrial community.

Under alternative B-1, continued erosion and degradation of the foredune complex would diminish and reduce continued colonization by invasive and nonnative plant species. Revegetation, along with colonization of native plant species would help to prevent nonnative invasive plant species from dominating the area, and have a minor, short-term, beneficial impact on terrestrial habitat. Implementing the actions associated with alternative B-1 would improve the ability of the beach to withstand storm events and preserve terrestrial habitat for plants and animals, thereby having a negligible to minor, short-term, beneficial effect.

Actions under alternative B-1 would forestall continued erosion and degradation and provide for a greater amount of sediment added to reach 1 than provided in the past. This beach nourishment, coupled with revegetation in nonsensitive areas, would benefit the terrestrial habitat of native plant and animal communities and have a minor, short-term, beneficial impact; however, a minor, short-term, adverse impact would also result from covering/smothering existing plant species during sediment placement. Plant species endemic to the beach plant community would re-emerge, and colonization and revegetation would provide the basis for a stable system in reach 1. In addition, some nonnative, invasive species would be present in the material from upland

sources, but park management practices, like the early detection and rapid response program and Invasive Plant Management Plan, include early identification and eradication of such species. Implementing actions under alternative B-1 would result in minor, short-term, adverse impacts on the terrestrial habitat for native plant and animal communities.

Cumulative Impacts. The same scenario of past, present, and reasonably foreseeable future actions described under the no-action alternative would also apply under alternative B-1. Compared to the cumulative impacts expected under the no-action alternative, under alternative B-1, these differences in relation to past, present, and reasonably foreseeable future projects would add a small increment. Cumulative impacts would be minor, short- and long-term and adverse and beneficial. Beneficial impacts would result from the decreased erosion and more stable habitat that would result under this alternative; adverse impacts would result from the temporary smothering of plants and plant and animal habitat during beach nourishment activities and from the temporary displacement of wildlife. Implementing the actions associated with alternative B-1 would provide a small incremental contribution to overall cumulative impacts.

Conclusion. Under alternative B-1, there would be minor, short-term, adverse impacts on terrestrial habitat for native plant and animal communities from the introduction of invasive nonnative plant species into the park during sediment placement activities. In addition, minor, short-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion, would occur under this alternative. Implementing the actions associated with alternative B-1 would improve the ability of the beach to withstand storm events, preserve terrestrial habitat for plants and animals, and result in a negligible to minor, short-term, beneficial effect. The actions under this alternative, when combined with other past, present, and reasonably foreseeable future actions, would have minor, short- and long-term and adverse and beneficial, cumulative effects.

Alternative B-5 (Beach Nourishment via Upland Sources, Five-Year Frequency)

The actions and impacts associated with alternative B-5 would be similar to those described above for alternative B-1, with a few differences. That is, under alternative B-5, there would be minor, short-term, adverse impacts from the introduction of invasive nonnative plant species in the park during sediment placement activities; negligible to minor, long-term, adverse effects from activities associated with revegetation that would affect sensitive habitats; minor, long-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion; and minor, long-term, beneficial impacts as continued erosion and degradation of the foredune would reduce continued colonization by invasive and nonnative plant species. Implementing the actions associated with alternative B-5 would improve the ability of the beach to withstand storm events, preserve terrestrial habitat for plants, and have a negligible to minor, long-term, beneficial effect.

Impacts under alternative B-5 would be greater than those under the annual beach nourishment proposed under alternative B-1 because of the longer duration (approximately 18 months every five years) of nourishment activities and the larger footprint of sediment placed on the beach. These actions under alternative B-5 would have moderate, long-term, adverse impacts on terrestrial habitat for native plant and animal communities. The recovery period between placements would be greater than under alternative B-1, which would enhance colonization by native species, and benefit restoration of habitat for threatened and endangered species and species of concern and management of nonnative invasive plant species.

Cumulative Impacts. The same scenario of past, present, and reasonably foreseeable future actions described under the no-action alternative would also apply under alternative B-5. Compared to the cumulative impacts expected under the no-action alternative, under alternative B-5, these differences in relation to past, present, and reasonably foreseeable future projects would result in a large incremental addition to the cumulative environment. Cumulative impacts would be minor to moderate, short- and long-term and adverse and beneficial from the longer duration (approximately 18 months every five years) of sediment placement and from the larger footprint of placement. The actions associated with alternative B-5 would provide a large contribution to overall cumulative impacts.

Conclusion. Under alternative B-5, there would be minor, long-term, adverse impacts on terrestrial habitat for native plant and animal communities from the introduction of invasive nonnative plant species into the park during sediment placement activities; minor, long-term, beneficial impacts from nourishment of the park shoreline; moderate, long-term, adverse impacts from the longer duration (approximately 18 months every five years) of nourishment activities and the larger footprint of sediment placed on the beach; minor, long-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion; and minor, long-term, beneficial impacts as continued erosion and degradation of the foredune would reduce continued colonization by invasive and nonnative plant species. Additionally, the actions associated with alternative B-5 would improve the ability of the beach to withstand storm events, preserve terrestrial habitat for plants.

The actions under this alternative, when combined with other past, present, and reasonably foreseeable future actions, would have moderate, short- and long-term, adverse and beneficial, cumulative effects.

Alternative C-1 (Beach Nourishment via Dredged Sources, Annual Frequency)

The actions and impacts associated with alternative C-1 would be similar to those described under alternative B-1. That is, under alternative C-1, there would be negligible to minor, short-term, adverse effects from revegetation that would affect sensitive habitats; and minor, short-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion. Given the importance of beach nourishment in reducing loss of terrestrial habitat and enhancing the ability to manage nonnative invasive species under this alternative, the impacts would be minor, short-term and beneficial as nourishment material placed would be dredged from an updrift location, such as the nearshore area east of the Michigan City Harbor, and not be likely to introduce weed seeds to the shoreline and beach complex. The actions associated with alternative C-1 would improve the ability of the beach to withstand storm events, preserve terrestrial habitat for plants, and have a negligible to minor, short-term, beneficial effect.

Cumulative Impacts. The same scenario of past, present, and reasonably foreseeable future actions described under the no-action alternative would also apply under alternative C-1. Compared to the cumulative impacts expected under the no-action alternative, under alternative C-1, these differences in relation to past, present, and reasonably foreseeable future projects would result in a small increment being added to the cumulative environment. Cumulative impacts would be minor, short- and long-term and adverse and beneficial. Adverse impacts would result from the temporary disturbance to plant and animal terrestrial habitat during placement activities; beneficial impacts would result from the decreased erosion and improved natural habitat for plants and animals. The actions associated with alternative C-1 would provide a small

incremental contribution to overall cumulative impacts.

Conclusion. Under alternative C-1, there would also be negligible to minor, short-term, adverse effects from revegetation that would affect sensitive habitats. Additionally, minor, short-term, beneficial impacts would result from nourishment of the park shoreline, particularly in areas of accelerated erosion. The actions associated with alternative C-1 would improve the ability of the beach to withstand storm events, preserve terrestrial habitat for plants, and have a negligible to minor, short-term, beneficial effect. Under this alternative, material would be dredged from an updrift location, and have no or limited viable nonnative invasive plant species seedbank, resulting in a negligible to minor, short-term, beneficial effect on terrestrial habitat. The actions associated with this alternative, when combined with other past, present, and reasonably foreseeable future actions, would have minor, short- and long-term and adverse and beneficial, cumulative effects.

Alternative C-5 (Beach Nourishment via Dredged Sources, Five-Year Frequency)

The actions and impacts associated with alternative C-5 would be similar to those described under alternative C-1 with a few differences. Impacts under alternative C-5 would be greater than those under the annual nourishment proposed under alternative C-1 because of the longer duration (approximately 10 months every five years) of nourishment activities and the larger footprint of sediment placed on the beach, resulting in moderate, long-term, adverse effects from the smothering of plants and plant and animal terrestrial habitat during placement activities. The recovery period between placements under alternative C-5 would be longer than under alternative C-1, which would enhance colonization by native species, and benefit restoration of habitat for threatened and endangered species and species of concern and manage nonnative invasive plant species. These actions under alternative C-5 would have moderate, short-term, beneficial impacts on terrestrial habitat for native plant and animal communities.

Cumulative Impacts. The same scenario of past, present, and reasonably foreseeable future actions described under the no-action alternative would also apply under alternative C-5. Compared to the cumulative impacts expected under the no-action alternative, under alternative C-5, these differences in relation to past, present, and reasonably foreseeable future projects would result in a large difference. Cumulative impacts would be minor to moderate, short- and long-term and adverse and beneficial. Adverse impacts would result from the disturbance to plant and animal terrestrial habitat during placement activities; beneficial impacts would result from the decreased erosion and improved natural habitat for plants and animals following placement activities. The actions associated with alternative C-5 would provide a large contribution to overall cumulative impacts.

Conclusion. Under alternative C-5, there would be moderate, short-term, beneficial impacts from nourishment of the park shoreline; and moderate, long-term, adverse impacts from the longer duration (approximately 10 months every five years) of nourishment activities and the larger footprint of sediment placed on the beach. The actions associated with alternative C-5 would improve the ability of the beach to withstand storm events, preserve terrestrial habitat for plants, and introduce no or limited viable nonnative invasive plant species seedbank since material would be dredged from an updrift location, such as the nearshore area east of the Michigan City Harbor, having negligible to minor, long-term beneficial effects on terrestrial habitat for plants and animals. The actions associated with this alternative, when combined with other past, present, and reasonably foreseeable future actions, would have minor to moderate, short- and long-term and adverse and beneficial, cumulative effects.

Alternative D (Beach Nourishment via Permanent Bypass System)

The actions and impacts associated with alternative D would be similar to those described under alternative C-1. That is, there would be negligible to minor, short-term, adverse effects from revegetation that would affect sensitive habitats, such as those utilized by the piping plover (*Charadrius melodus*). And, there would be minor, short-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion. The continuation of sediment placement in reach 1 would have limited potential to introduce invasive and nonnative plant species under alternative D because of the clean sediment source for the beach nourishment material. Given the importance of beach nourishment in reducing loss of terrestrial habitat and enhancing the ability to manage nonnative invasive plant species, the impacts under alternative D would be minor, short-term and beneficial because the beach nourishment material would be transported to reach 1 via a permanent bypass system from updrift of the Michigan City Harbor and not be likely to introduce weed seeds to the shoreline and beach complex. The actions associated with alternative D would improve the ability of the beach to withstand storm events, preserve terrestrial habitat for plants, and have a negligible to minor, short-term, beneficial effect.

The actions associated with alternative D would involve increasing the amount of sediment placed in the project area through a permanent bypass system, thereby decreasing degradation of the beach and consequently the foredune plant communities. These actions would have minor, short-term, adverse impacts, as some beach vegetation would be smothered during placement. There would also be minor, short-term, beneficial impacts from the decreased erosion and improved natural ecological setting for native plants and animals to thrive on.

Cumulative Impacts. The same scenario of past, present, and reasonably foreseeable future actions described under the no-action alternative would also apply under alternative D. Compared to the cumulative impacts expected under the no-action alternative, under alternative D, these differences in relation to past, present, and reasonably foreseeable future projects would result in a small change. Cumulative impacts would be minor, short- and long-term and adverse and beneficial. Adverse impacts would result from the temporary disturbance to plant and animal terrestrial habitat during placement activities; beneficial impacts would result from the decreased erosion and improved natural habitat for plants and animals. The actions associated with alternative D would provide a small incremental contribution to overall cumulative impacts.

Conclusion. Under alternative D, there would be negligible to minor, short-term, adverse effects from revegetation that would affect sensitive habitats, and there would be minor, short-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion. The actions associated with alternative D would involve increasing the amount of sediment placed in the project area through a permanent bypass system, thereby decreasing degradation of the beach and consequently the foredune plant communities. As some beach vegetation would be smothered during placement, actions under alternative D would have minor, short-term, adverse impacts, but also minor, short-term, beneficial impacts from the decreased erosion and improved natural ecological setting for native plants and animals. The actions associated with alternative D would improve the ability of the beach to withstand storm events and preserve terrestrial habitat. The actions of this alternative, when combined with other past, present, and reasonably foreseeable future actions, would have minor, short- and long-term and adverse and beneficial, cumulative effects.

Alternative E (Submerged Cobble Berm and Beach Nourishment, Annual Frequency)

Like the other action alternatives, the actions associated with alternative E would allow for increased beachfront, thereby providing the potential for dune stabilization, particularly at Mount Baldy. Foredune development would be feasible under this alternative, too, with sediment supply, wind, and an entrapment feature, such as vegetation. In conjunction with the restoration alternative selected, terrestrial management practices, such as revegetation in areas of erosion, would promote the formation of foredunes. Foredune formation would provide habitat connectivity and sustainability and contribute sediment (via natural erosion) to the coastal system. These actions would have minor, long-term, beneficial impacts on terrestrial habitat for native plant and animal communities. Restoration of the park shoreline, particularly in areas of accelerated erosion, through the use of the submerged cobble berm proposed under alternative E, would result in minor, long-term, beneficial impacts on the terrestrial community. The actions associated with alternative E would improve the ability of the beach to withstand storm events, preserve terrestrial habitat for plants, and have a minor, long-term, beneficial effect.

Construction of a submerged cobble berm in reach 1 under alternative E would result in longer retention of sediment along the shoreline, thereby decreasing erosion of the beach and the foredune plant communities. While placement of sediment may cover existing vegetation and have minor, short-term, adverse effects, colonization and emergence of covered plants would occur, and have minor, short-term, beneficial impacts. In addition, terrestrial management, including revegetation and management of nonnative invasive plant species, would benefit the native plant community in areas of degradation. Management efforts would not be likely to introduce weed seeds to the shoreline and beach complex because under alternative E nourishment material placed would be obtained from a dredged source, located east, updrift of the Michigan City Harbor structure.

Cumulative Impacts. The same scenario of past, present, and reasonably foreseeable future actions described under the no-action alternative would also apply under alternative E. Compared to the cumulative impacts expected under the no-action alternative, under alternative E, these differences in relation to past, present, and reasonably foreseeable future projects would result in a small change. Cumulative impacts would be minor, short- and long-term and adverse and beneficial. Adverse impacts would result from the temporary disturbance to plant and animal terrestrial habitat during placement activities; however, these impacts would be reduced from current impact levels due to the decreased volume of dredged beach nourishment that would be required annually with the addition of a submerged cobble berm that would gradually dissipate. Beneficial impacts would result from the decreased erosion and improved natural habitat for plants and animals, and the reduction in annual beach nourishment volumes. The actions associated with alternative E would provide a small incremental contribution to overall cumulative impacts.

Conclusion. Under alternative E, there would be minor, long-term, beneficial impacts on terrestrial habitat for native plant and animal communities from dune stabilization and foredune development; minor, long-term, adverse effects on sensitive habitats from interfering with an already stable area in reach 2; and minor to moderate, long-term, beneficial impacts from restoration of the park shoreline, particularly in areas of accelerated erosion. Impacts would be less than those from the previously described annual beach nourishment activities under alternatives B-1 and C-1. Impacts would be minor to moderate, long-term and beneficial from the reduced consumption of material for nourishment activities. The actions associated with alternative E would improve the ability of

the beach to withstand storm events and preserve terrestrial habitat for plants and animals. The actions associated with this alternative, when combined with other past, present, and reasonably foreseeable future actions, would have minor, short- and long-term, adverse and beneficial, cumulative effects.

Alternative F (Beach Nourishment, Annual Frequency with a Mix of Small Natural Stones at the Shoreline) – Preferred Alternative

The actions associated with alternative F, the preferred alternative, would allow for increased beachfront, thereby providing the potential for dune stabilization, particularly at Mount Baldy. Foredune development would be feasible with sediment supply, wind, and an entrapment feature, such as vegetation. In conjunction with the restoration alternative selected, terrestrial management practices, such as revegetation in areas of erosion, would promote the formation of foredunes. Foredune formation would provide habitat connectivity and sustainability and contribute sediment (via natural erosion) to the coastal system. These actions would have minor, long-term, beneficial impacts on terrestrial habitat for native plant and animal communities. Restoration of the park shoreline, particularly in areas of accelerated erosion, through the implementation of beach nourishment with a mix of small natural stone, dredged sediment, and coarse upland material at the shoreline under alternative F, would result in minor, long-term, beneficial impacts on the terrestrial community. The actions associated with alternative F would improve the ability of the beach to withstand storm events, preserve terrestrial habitat for plants, and have a minor, long-term, beneficial effect.

Beach nourishment with a mix of small natural stone, dredged sediment, and coarse upland material along the shoreline on an annual frequency in reach 1 under alternative F would result in longer retention of sediment along the shoreline, thereby decreasing erosion of the beach and the foredune plant communities. While placement of sediment may cover existing vegetation and have minor, short-term, adverse effects, colonization and emergence of covered plants would occur and have minor, short-term, beneficial impacts. In addition, terrestrial management, including revegetation and management of nonnative invasive plant species, would benefit the native plant community in areas of degradation. Management efforts would not be likely to introduce weed seeds to the shoreline and beach complex because under alternative F nourishment material placed would be obtained from a dredged source, located updrift of the Michigan City Harbor structure.

Cumulative Impacts. The same scenario of past, present, and reasonably foreseeable future actions described under the no-action alternative would also apply under the preferred alternative. Compared to the cumulative impacts expected under the no-action alternative, under alternative F, these differences in relation to past, present, and reasonably foreseeable future projects would result in a small change. Cumulative impacts would be minor, short- and long-term, and adverse and beneficial. Adverse impacts would result from the temporary disturbance to plant and animal terrestrial habitat during placement activities; however, these impacts would be reduced from current impact levels due to the decreased volume of dredged beach nourishment that would be required annually along with the mix of small natural stone, dredged sediment, and coarse upland material at the shoreline. Beneficial impacts would result from the decreased erosion and improved natural habitat for plants and animals, and the reduction in annual beach nourishment volumes. The actions associated with alternative F would provide a small incremental contribution to overall cumulative impacts.

Conclusion. Under alternative F, there would be minor, long-term, beneficial impacts on terrestrial habitat for native plant and animal communities from dune stabilization and

foredune development; minor, long-term, adverse effects on sensitive habitats from interfering with an already stable area in reach 2; and minor to moderate, long-term, beneficial impacts from restoration of the park shoreline, particularly in areas of accelerated erosion. Impacts would be less than those from the previously described annual beach nourishment activities under alternatives B-1 and C-1. Impacts would be minor to moderate, long-term, and beneficial from the reduced consumption of material for beach nourishment activities. The actions associated with the preferred alternative would improve the ability of the beach to withstand storm events and preserve terrestrial habitat for plants and animals. The actions associated with this alternative, when combined with other past, present, and reasonably foreseeable future actions, would have minor, short- and long-term, adverse and beneficial, cumulative effects.

SHORELINE AND BEACH COMPLEX, REACHES 3 AND 4

Alternative A (No-action Alternative)

Under the no-action alternative for reaches 3 and 4, there would be no new impacts on the terrestrial habitat of native plant and animal communities in the park, and the actions associated with this alternative would neither invite nor deter invasive species from inhabiting the shoreline and beach complex in reaches 3 and 4. Under alternative A, the current trend of destabilization of the foredunes would continue, especially at Portage Lakefront and Riverwalk. Such destabilization would lead to the localized loss of the natural ecosystems associated with the beach and the foredunes, including plant species endemic to the dunes, as well as insects, reptiles, birds, and mammals dependent upon this habitat. Implementation of the no-action alternative would have minor, short- and long-term, adverse impacts on the terrestrial habitat for native plant and animal communities.

Continued erosion in the vicinity of Portage Lakefront and Riverwalk would be likely under the no-action alternative despite the introduction of dredged material from ongoing beach nourishment activities and habitat loss would continue from the erosion. The possibility of establishing a natural ecosystem is unlikely under the no-action alternative. Taking no new actions in the park would lead to minor, short- and long-term, adverse impacts on the terrestrial habitat for native plant and animal communities. Under alternative A, the beach would continue to erode and would not be able to withstand storm events.

Cumulative Impacts. The cumulative impacts under alternative A in reaches 3 and 4 would be similar to those described above under the no-action alternative for reaches 1 and 2. That is, overall, when the actions described above are combined with the existing terrestrial habitat for native plant and animal communities, there would be minor to moderate, short- and long-term, adverse and beneficial, cumulative impacts. The actions under alternative A would add a small increment to the overall cumulative impact.

Conclusion. Under alternative A, there would be no new actions taken in the park, including any actions to invite or deter invasive and nonnative plants. If no new actions are taken in the park, there would continue to be minor, short- and long-term, adverse impacts on the terrestrial habitat of native plant and animal communities from the ongoing erosion and destabilization. Taking no new actions in the park would not improve the ability of the beach to withstand storm events. Cumulatively, there would be minor to moderate, short- and long-term, adverse and beneficial, cumulative impacts on the terrestrial habitat of native plant and animal communities. The actions under alternative A would result in a small increment being added to the overall cumulative impact.

Alternative C-1 (Beach Nourishment via Dredged Sources, Annual Frequency) – Preferred Alternative

The actions and impacts associated with the preferred alternative for reaches 3 and 4 would be similar to those described above under alternative C-1 for reaches 1 and 2 with a few differences. Under alternative C-1 in reaches 3 and 4, beach erosion in the vicinity of Portage Lakefront and Riverwalk would diminish as a result of dredged material being added to the beach near Ogden Dunes. Under alternative C-1, there would be negligible to minor, short-term, adverse effects from activities associated with revegetation that would interfere with stable reaches along the shoreline and affect sensitive habitats. In addition, minor, short-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion, would result under this alternative. The actions associated with alternative C-1 would have negligible to minor, short-term, adverse impacts as some beach vegetation would be smothered during placement activities; however, the potential for site restoration would be enhanced since the amount of beach nourishment would counteract erosion, and have a minor, short-term, beneficial impact. Given the importance of beach nourishment in reducing loss of terrestrial habitat and enhancing the ability to manage nonnative invasive species, impacts under alternative C-1 would be negligible to minor, short-term and beneficial since material dredged from an updrift location in Lake Michigan would have no or a limited viable nonnative invasive plant species seedbank. The actions associated with alternative C-1 would improve the ability of the beach to withstand storm events, preserve terrestrial habitat for plants, and have a negligible to minor, short-term, beneficial effect.

Additionally, bank swallows (*Riparia riparia*) nest in the foredune "cliff" area created as a result of shoreline erosion. As nourishment material placed on the beach under alternative C-1 would stabilize the shoreline and combat the high rates of erosion, these eroded cliff areas would be reduced, potentially removing the swallows of a suitable nesting habitat, particularly during the placement of the nourishment material. If the eroded cliff was reduced through beach nourishment activities associated with alternative C-1, the terrestrial habitat for the bank swallow would be reduced. There are a few suitable sites for this habitat along Burns International Harbor, which would provide an alternative site for the birds, unless the COE completes a restoration project along the waterway that would involve eliminating the steep, open banks. The ephemeral nature of the species' natural nesting venues of muddy banks, dunes, and lakeshores makes this species well-adapted to re-finding appropriate habitat year-after-year (FWS 2007b). Beach nourishment activities under alternative C-1 would reduce erosion and the subsequent maintenance of eroded cliff areas for the birds resulting in minor, short-term, adverse impacts to the bank swallow as they would lose immediate habitat. However, the birds would relocate to other suitable habitat in the near vicinity. Work would be conducted outside critical periods (such as nesting) for these specific species when possible.

Cumulative Impacts. The same scenario of past, present, and reasonably foreseeable future actions described under the no-action alternative would also apply under alternative C-1. Compared to the cumulative impacts expected under the no-action alternative, under alternative C-1, these differences in relation to past, present, and reasonably foreseeable future projects would result in a small change. Cumulative impacts would be minor, short- and long-term and adverse and beneficial. Adverse impacts would result from the temporary disturbance to plant and animal terrestrial habitat during placement activities; beneficial impacts would result from the decreased erosion and improved natural habitat for plants and animals. The actions associated with alternative C-1 would provide a small incremental contribution to overall cumulative impacts.

Conclusion. Under the preferred alternative, there would be negligible to minor, short-term, adverse effects from revegetation that would affect sensitive habitats, in addition to minor, short-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion. The actions associated with alternative C-1 would have negligible to minor, short-term, adverse impacts as some beach vegetation would be smothered during placement; however, the potential for site restoration would be enhanced since the amount of beach nourishment would counteract erosion, and have a minor, short-term, beneficial impact. Impacts under alternative C-1 would be negligible to minor, short-term and beneficial, since material dredged from an updrift location in Lake Michigan would have no or limited viable nonnative invasive plant species seedbank. The actions associated with alternative C-1 would improve the ability of the beach to withstand storm events and preserve terrestrial habitat for plants and animals. Beach nourishment activities under alternative C-1 would reduce erosion and the subsequent maintenance of eroded cliff areas for the bank swallows resulting in minor, short-term, adverse impacts to these birds as they would lose immediate habitat. This alternative, when combined with other past, present, and reasonably foreseeable future actions, would have minor, short- and long-term and adverse and beneficial, cumulative effects.

Alternative C-5 (Beach Nourishment via Dredged Sources, Five-Year Frequency)

The actions and impacts associated with alternative C-5 for reaches 3 and 4 would be similar to those described above under alternative C-1, with a few differences. Impacts would be greater under alternative C-5 than under the annual beach nourishment proposed under alternative C-1 because of the longer duration (approximately six months every five years) of nourishment activities and the larger footprint of sediment placed on the beach. Under alternative C-5, there would be negligible to minor, short-term, adverse effects from revegetation that would affect sensitive habitats; moderate, short-term, beneficial impacts from nourishment of the park shoreline; and moderate, long-term, adverse impacts from the longer duration (approximately six months every five years) of nourishment activities and the larger footprint of sediment placed on the beach. The actions associated with alternative C-5 would improve the ability of the beach to withstand storm events and preserve terrestrial habitat for plants. Nourishment material dredged from an updrift location in Lake Michigan would have no or limited viable nonnative invasive plants species seedbank, having a negligible to minor, long-term, beneficial effect.

A minor, long-term, adverse impact would occur on bank swallows that nest along the eroded cliffs in reach 4 under alternative C-5, as beach nourishment would reduce erosion and cliff-forming processes, reducing the terrestrial habitat for the bank swallow. As indicated under alternative C-1 for reaches 3 and 4, the birds would relocate to other suitable habitat in the near vicinity. Work would be conducted outside critical periods (such as nesting) for these specific species when possible.

Cumulative Impacts. The same scenario of past, present, and reasonably foreseeable future actions described under the no-action alternative would also apply under alternative C-5. Compared to the cumulative impacts expected under the no-action alternative, under alternative C-5, these differences in relation to past, present, and reasonably foreseeable future projects would result in a small change. Cumulative impacts would be minor to moderate, short- and long-term and adverse and beneficial. Adverse impacts would result from the disturbance to plant and animal terrestrial habitat during placement activities; beneficial impacts would result from the decreased erosion and improved natural habitat for plants and animals and the improved ability of the beach to withstand storm events. The actions

associated with alternative C-5 would provide a small incremental contribution to overall cumulative impacts.

Conclusion. Under alternative C-5, there would also be negligible to minor, short-term, adverse effects from revegetation that would affect sensitive habitats, in addition to moderate, short-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion. The actions associated with alternative C-5 would also result in moderate, long-term, adverse effects on terrestrial habitat from the longer duration (approximately six month every five years) of placement activities and the larger placement footprint. The actions associated with alternative C-5 would improve the ability of the beach to withstand storm events and preserve terrestrial habitat for plants and animals, and would introduce no or limited viable nonnative invasive plant species seedbank since material would be dredged from an updrift location, having negligible to minor, long-term beneficial impacts on terrestrial habitat. A minor, long-term, adverse impact would occur on bank swallows that nest along the eroded cliffs in reach 4 under alternative C-5, as beach nourishment would reduce erosion and cliff-forming processes, reducing the terrestrial habitat for the bank swallow. The actions associated with this alternative, when combined with other past, present, and reasonably foreseeable future actions, would have minor, short- and long-term and adverse and beneficial, cumulative effects.

Alternative D (Beach Nourishment via Permanent Bypass System)

The actions and impacts associated with alternative D for reaches 3 and 4 would be similar to those above under alternative D for reaches 1 and 2, with a few differences. That is, negligible to minor, short-term, adverse impacts from revegetation that would affect sensitive habitats; and minor, short-term, beneficial impacts from nourishment of the park shoreline. The actions associated with alternative D would involve increasing the amount of sediment placed in the project area through a permanent bypass system, thereby decreasing degradation of the beach and consequently the foredune plant communities, and have minor, short-term, adverse impacts as some beach vegetation would be smothered during placement; and also minor, short-term, beneficial impacts from the decreased erosion and an improved natural terrestrial habitat for native plants to thrive.

Under alternative D, beach erosion in the vicinity of Ogden Dunes would diminish as a result of additional material being added to the beach via a permanent bypass system. The addition of beach material would lead to foredune development and habitat loss would diminish. The establishment of a natural ecosystem would be likely through site restoration. Under alternative D, there would be negligible to minor, short-term, adverse impacts as some beach vegetation could be smothered during placement; however, the potential for site restoration would be enhanced, since the amount of beach nourishment would counteract erosion. The actions associated with alternative D would improve the ability of the beach to withstand storm events, preserve terrestrial habitat for plants and animals, and introduce no or limited viable nonnative invasive plants species seedbank since material would be transported to reach 3 via a permanent bypass system from updrift of the NIPSCO/Bailly complex to Portage Lakefront and Riverwalk, and have a negligible to minor, short-term, beneficial effect.

A minor, short-term, adverse impact would occur on bank swallows that nest along the eroded cliffs in reach 4 under alternative D, as beach nourishment would reduce erosion and cliff-forming processes, reducing the terrestrial habitat for the bank swallow. As indicated under alternative C-1 for reaches 3 and 4, the birds would relocate to other suitable habitat in the near vicinity. Work would be conducted outside critical periods

(such as nesting) for these specific species when possible.

Cumulative Impacts. The same scenario of past, present, and reasonably foreseeable future actions described under the no-action alternative would also apply under alternative D. Compared to the cumulative impacts expected under the no-action alternative, under alternative D, these differences in relation to past, present, and reasonably foreseeable future projects would result in a small change. Cumulative impacts would be minor, short- and long-term and adverse and beneficial. Adverse impacts would result from the temporary disturbance to plant and animal terrestrial habitat during placement activities; beneficial impacts would result from the decreased erosion and improved natural habitat for plants and animals, and improved ability of the beach to withstand storm events. Implementing the actions associated with alternative D would provide a small incremental contribution to overall cumulative impacts.

Conclusion. Under alternative D, there would also be negligible to minor, short-term, adverse effects from revegetation that would affect sensitive habitats; and there would be minor, short-term, beneficial impacts from nourishment of the park shoreline, particularly in areas of accelerated erosion. The actions associated with alternative D would involve increasing the amount of sediment placed in the project area through a permanent bypass system, thereby decreasing degradation of the beach and consequently the foredune plant communities. The actions associated with alternative D would result in minor, short-term, adverse impacts as some beach vegetation would be smothered during placement, as well as minor, short-term, beneficial impacts from the decreased erosion and improved terrestrial habitat for native plants and animals to thrive on. The actions associated with alternative D would improve the ability of the beach to withstand storm events and preserve terrestrial habitat for plants, and would introduce no or limited viable nonnative invasive plant species seedbank since material would be transported to reach 3 via a permanent bypass system from updrift of the NIPSCO/Bailly complex. A minor, long-term, adverse impact would occur on bank swallows that nest along the eroded cliffs in reach 4 under alternative D, as beach nourishment would reduce erosion and cliff-forming processes, reducing the terrestrial habitat for the bank swallow. This alternative, when combined with other past, present, and reasonably foreseeable future actions, would have minor, short- and long-term and adverse and beneficial, cumulative effects.

FOREDUNE AND DUNE COMPLEX, REACHES 1 THROUGH 4

Current Management Actions

As explained in "The Alternatives" chapter, there are various current management actions of Indiana Dunes National Lakeshore that impact terrestrial habitat for plant and animal species in reaches 1 through 4.

Designation of an approved route from the parking lot to and from Mount Baldy in reach 1 has reduced the anthropogenic influences in that reach, including the trampling of native vegetation and the spread of invasive nonnative plant species, having a negligible to minor, long-term, beneficial impact on the habitat for native plant and animal communities.

Ongoing beach nourishment activities in reaches 1 and 3 have a minor, long-term, adverse impact from the smothering of native vegetation that occurs during sediment placement activities (and the subsequent period it typically takes native species to colonize and re-emerge as a stable population); however, these same activities result in minor, long-term, beneficial impacts from reduced erosion and improved ability of the shoreline to withstand storm events.

Restoration efforts (including installing fencing to protect environmentally sensitive areas and revegetating eroded areas with native vegetation) in the park have minor, long-term, beneficial impacts on terrestrial habitat for native plant communities by preserving and restoring the natural habitat and ecological processes that are critical to this vegetation's survival and reproduction in the park, and by improving the ability of the terrestrial habitat to withstand storm events. Similarly, visitor outreach and education efforts have minor, long-term, beneficial impacts on terrestrial habitat by increasing the knowledge base of visitors in the park and limiting the anthropogenic influences introduced and witnessed in the park.

Invasive vegetation management is performed in all the reaches of the park and includes an early detection and rapid response program and Invasive Plant Management Plan. This work manages the spread of invasive nonnative plants in the park and encourages early detection and eradication of such species, preserving the native habitat. These actions result in minor, long-term, beneficial impacts on the terrestrial habitat of native plant and animal communities.

Proposed Management Actions

Various proposed management actions at the park would impact terrestrial habitat for native plant and animal species in reaches 1 through 4.

The park would continue with the current management actions discussed above, having a minor, long-term, beneficial impact on terrestrial habitat for native plant and animal species by preserving and restoring critical habitat of native plant communities and preserving the ability of the habitat to withstand storm events. By continuing to manage nonnative invasive plant species, the National Park Service would provide a negligible to minor, long-term, beneficial effect on natural processes, including terrestrial habitat for plant communities in the park.

The proposed realigning of trails in the beach reaches would have minor, long-term, beneficial impacts on the terrestrial habitat for native plant and animal communities by limiting the anthropogenic influences witnessed in the park and by reducing the number of social trails (thereby reducing the trampling of native plant species).

Additionally, the park proposes to restore the foredune and dune complex in reach 4 by stabilizing eroded dunes with native vegetation and fencing off highly eroded and environmentally sensitive areas on the foredune to allow for ecological recovery of natural communities. Such work would have a minor, long-term, beneficial impact on the terrestrial habitat for native plant and animal communities by preserving and restoring the natural environment in which the species thrive and improving the ability of such habitat to better withstand storm events.

Cumulative Impacts. Proposed developments, including that proposed in Phase II of the Marquette Plan (IDNR *et al.* 2005), in and around the park would have a minor, short- and long-term, adverse effect on the terrestrial habitat of native plants as construction areas provide pathways for the introduction of invasive nonnative plant species. In addition, construction work would result in the trampling of native vegetation and destruction of critical habitat for native plant and animal species. Cumulative impacts on the foredune and dune complex in reaches 1 through 4 under terrestrial habitat as a result of proposed management actions would be negligible to minor, long-term, and beneficial from the actions proposed to preserve terrestrial plant and animal critical habitat and to protect environmentally sensitive areas to allow for ecological recovery of natural communities.

Conclusion. Impacts on the foredune and dune complex in reaches 1 through 4 under terrestrial habitat as a result of proposed

management actions would be negligible to minor, long-term, and beneficial from continuing with current management actions to protect and preserve terrestrial plant and animal critical habitat and to fence off highly eroded and environmentally sensitive areas to allow for ecological recovery of natural communities, and from the proposed realigning of trails in the beach reaches to limit anthropogenic influences and social trails experienced in the park, reducing the trampling of native plant species. Proposed developments in and around the park would have a minor, short-term, adverse effect on the terrestrial habitat of native plants as construction areas provide pathways for the introduction of invasive nonnative plant species and because construction work would result in the trampling of native vegetation and destruction of critical habitat for native plant and animal species. Cumulative impacts on the foredune and dune complex in reaches 1 through 4 under terrestrial habitat as a result of proposed management actions would be negligible to minor, long-term, and beneficial.